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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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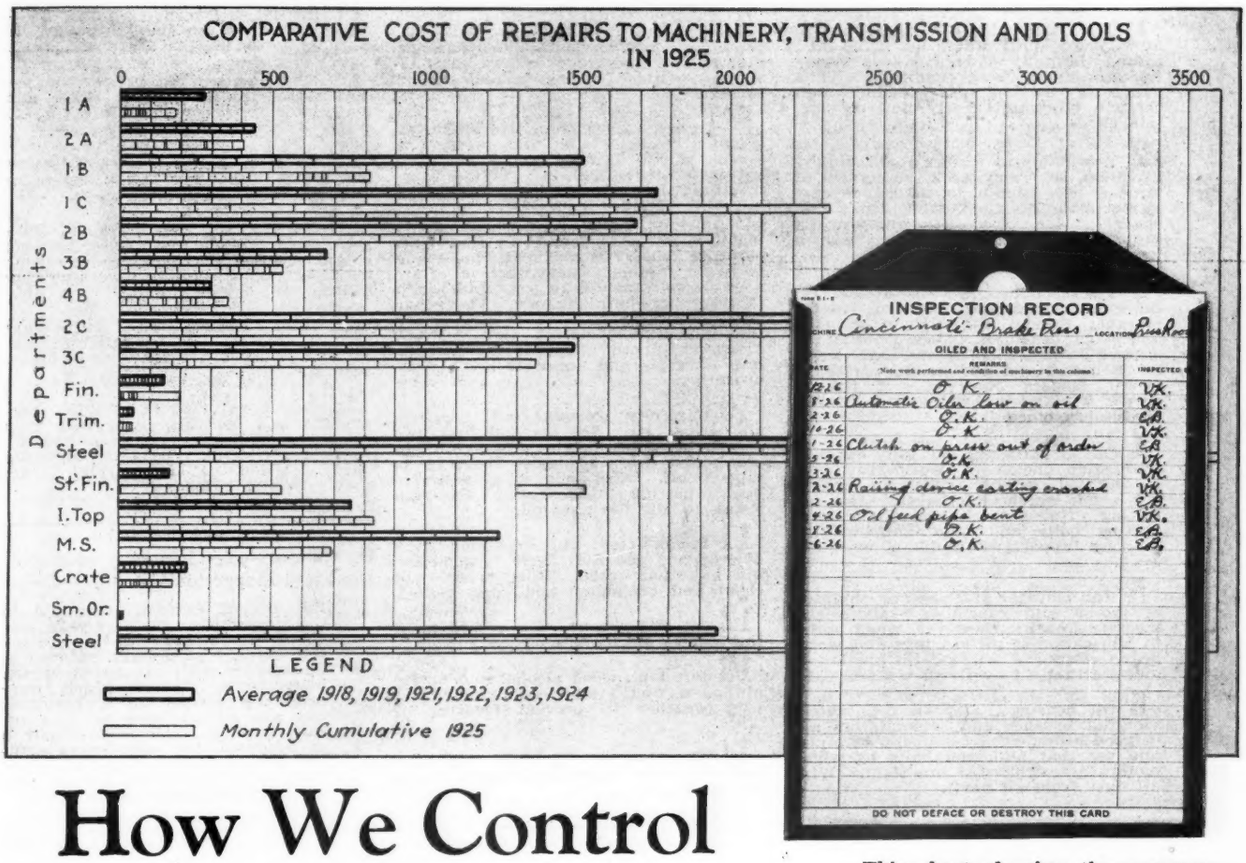


This chart showing the comparative costs of repairs and the Inspection Record are the two key points in the control of maintenance and repairs and their cost.

At each inspection period the inspector enters the condition of the machine on the Inspection Record. He thus discovers trouble before it becomes serious and keepes the repair costs low. By means of the chart each foreman can see just how his monthly cost record compares with the average performance of previous years.

How We Control Our Maintenance Costs

By THOS. W. SUDDARD

Secretary, The Hamilton Manufacturing Company, Two Rivers, Wis.

ONE of the very common weak spots in most methods of controlling maintenance and repair costs is that the management either makes a drive to keep everything up in first-class repair and later finds that the cost is too high, which sometimes causes a swing to the other extreme, or it places too much emphasis on a low maintenance cost, which often defeats its own ends because postponed maintenance is always more expensive.

Our plant is no different from others in having to face this problem of reliable maintenance at low cost. However, we believe that we are solving it about as satisfactorily as possible. No plan which depends upon judgment in determining how long a repair can be delayed before it becomes a breakdown can ever be 100 per cent perfect.

The plan in use at the Hamilton Manufacturing Company's plant is based on regular, systematic and thorough inspections of all machinery and equipment, and itemized reports of all maintenance and other costs for every foreman. These costs are also charted and compared with previous costs so that the management can see the trend at a glance. In addition to these, we have various meetings where maintenance and the other plant operating costs are discussed in detail, as will be explained later in the article.

The equipment inspection plan has been in effect about 15 yr. and in general principle and method of

Instructions Accompanying Inspection Chart

THE paragraphs below contain more detailed instructions on the duties connected with the inspection of each type of equipment than could be entered in the "Duties" column in the accompanying Inspection Chart. The numbers in the "Duties" column refer to the corresponding paragraph numbers below.

1 Run pump with discharge open to atmosphere until water is lifted and passed through. This will keep valves free and in working condition. While pump is moving pass cylinder oil through lubricator freely and oil outside parts.

2 This pump to receive regular daily attention, but every week the number of strokes per minute in actual service, and number of s.p.m. with water discharge valve closed (steam throttle same position) shall be recorded on inspection sheet.

3 The sprinkler systems are to receive same general attention as at present. Special inspection to be made and gage pressures indicated must be entered on inspection sheets. All alarms to be tested and annunciator drops in Power Houses observed. If not in proper working order report to Master Mechanic's office.

4 Oil all parts and carefully examine lubrication inside of worm-gear box. Inspect all safety appliances, cables, gates, and overhead sheaves. Also, all belting driving the machine and supporting bolts and nuts, both on the hoisting apparatus and on overhead work.

5 Run elevator and observe condition of motor and controller. Make immediate repairs, however small. See to lubrication of all bearings and worm gear. Examine all safety appliances and see that all overhead work is safe.

6 Oil bearings, and on d.c. motors see that brushes and commutators are in good order. Examine belts carefully and see that nuts and bolts by which motors are suspended are tight. Wipe all dust from all parts.

7 Blow dust from windings with compressed air and wipe clean. This means that motors and compensators shall be well kept so far as cleanliness is concerned.

8 Change valves from live steam to exhaust steam 7 a.m. and reverse at 6 p.m., during heating period of year; valves located: ..... Wind thermostats twice each day; located: .....

9 During time of year when outside temperature is 40 deg. F. or less, temperature observations shall be made twice in forenoon and twice in afternoon; also, once at 10 p.m. and again at 4 a.m. by the night man. The water shall never be allowed to get colder than 40 deg. F. Each time heating steam is turned on engineer shall go into tank pit and see if it is properly operating.

10 Carefully examine all bearings and drive belt. See that oil in crank case is of proper height. Change oil in crank case every 90 days. When oil is tapped off, wash out with kerosene before putting in fresh oil. Requires 5 gal. to fill; use auto oil.

11 Steam-fitter will examine oiling devices and see that there is sufficient oil in crank case. Electrician will clean and oil motor and compensator.

12 Oil and repair. The record is in the Master Mechanic's office.

13 Put 1 pt. wood alcohol into feeder at 8 a.m. and 3 p.m. each day during cold weather to prevent freezing of pipes.

14 Examine belt carefully for open laps and make immediate repairs if any are found.

15 Examine general condition of bulkhead at river front and suction well.

16 Inspect pump and motor twice each day when in operation and keep well cleaned and oiled.

17 Inspect each morning during heating season and see that traps are in working order; location of traps: .....

18 Make general inspection and see that traps are in working order and not blowing through; location of traps: .....

19 Examine every firedoor in plant and see that they are in working order and not obstructed.

20 See that all firepails are in place and filled; also, that water is not stagnant. See that hose connected to sprinkler risers is in good working condition.

21 Make complete tour of entire plant and observe general condition of machinery. Collect written notes of observations.

22 Inspect all valves, piping, thermostats and controls. Interview man in charge to get complaints and information regarding behavior of apparatus. When not in working order notify master mechanic.

On the next page is a copy of one of the early Inspection Charts.

Because of extensive changes in the plant during the past year, this chart would have to be revised considerably at present. However, it, together with the accompanying instructions, all of which were originally placed on a blueprint but are shown here in type for easy reading, indicate the method of approach for installing a similar system which, of course, would have to be worked out for the particular plant problems involved.

application is practically the same as when inaugurated. Previous to that time the plant had been operating on the plan of doing maintenance when it was found necessary, but seldom found it until a breakdown occurred. Breakdowns interfere with production and are much more costly than if the cause had been remedied earlier.

Our Mechanical Superintendent at that time, who had to bear much of the trouble caused by these breakdowns and was devoting considerable attention towards devising a plan to anticipate and so prevent much of the trouble, noticed the stenciled notation, "Inspected" which was followed by the date, on the air-brake cylinder of a freight car. He had seen this many times before, but this time he got the idea of applying a similar method of systematic inspection to the machinery and equipment in the plant.

Instead of stenciling the date of the inspection on the machine, however, an Inspection Record card is used. One of these cards, a filled-in sample of which is shown at the top of page 47, is used for each machine. At first all cards were placed in the metal card holder and the surface protected with a sheet of celluloid. This protection has been discarded as unnecessary except in the dirtier locations. The card is hung on the wall or on a column near the machine. The machinist who makes the inspection notes the date and anything he finds wrong, or adds his OK, and enters his initials in the last column.

Whenever anything is found which is likely to cause trouble, the inspector reports it to the foreman and a Maintenance Shop Order is issued at once. If the foreman does not issue an order to have the trouble corrected, the inspector reports it to his superior. However, the foremen are so thoroughly sold on the reduction in maintenance and repair costs which results from remedying any minor defect before it causes real trouble that a refusal is practically unknown.

Many of the troubles which show up should have been reported by the operator to his foreman. However, men experienced in plant operation know that the operator will seldom complain about the machine as long as it will get out the scheduled production. A bent oil pipe means nothing to him, at least until it clogs up. Usually, however, by that time a bearing must be replaced also. The increased cost, due to the renewal of the bearing, would probably amount to several times as much as the inspections cost for the year.

The cost of these inspections is charged to the department according to the time spent in that department

INSPECTION CHART

MACHINE	LOCATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	DUTIES
Fire Pump	Old Power H'se.	O		O		O		O		O		O		O		O		O		O		O		O		O		O		O		O	1
General Service Pump	Old Power H'se.	O						O						O				O						O								O	2
Sprinkler Risers	Entire Plant	S							S							S						S						S					3
Belt-Driven Elevators	Entire Plant		S							S							S						S						S				4
Electric Elevators	Warehouse		S	E						S	E						S	E						S	E						S	E	5
Power Motors	Entire Plant	E							E							E						E						E					6
Power Motors	Entire Plant	E														E																	7
Steam Heating	Entire Plant	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	8
Sprinkler Tank	Next to Office	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	9
Air Compressor	1st. Steel		S			S			S			S			S			S			S			S				S				10
Air Compressor	4th. Warehse.		S			S			S			S			S			S			S			S				S				11
Portable Electric Drills	Steel Plant	E						E						E						E						E							12
Alcohol Feeder	2nd. Steel	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	13
Main belt, Engine	New Power H'se.	B		B		B		B		B		B		B		B		B		B		B		B		B		B					14
Main belt, Generator	New Power H'se.	B		B		B		B		B		B		B		B		B		B		B		B		B		B					14
Intake from River	Lumber Yard	O						O						O						O													15
Johnson Pump	Office Basem't.	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	16
Main Belt of Engine	Old Power H'se.		B			B			B			B			B			B			B			B				B					14
Low-Pressure Traps	Entire Plant		S					S								S				S				S				S					17
High-Pressure Traps	Entire Plant		S			S			S			S					S				S				S				S					18
Fire Doors	Entire Plant			W						W								W				W				W								19
Fire Pails and Hose	Entire Plant			W						W								W				W				W								20
Plant Inspection	Entire Plant															X																		21
Lumber Dry Kilns	Entire Plant				S							S							S				S				S							22
Steel Enamel Ovens	3rd. Steel				S							S							S				S				S							22
Wood Enamel Ovens	4th. Warehse.				S							S							S				S				S							22
Air Brush Equipment	4th. Warehse.									S														S										23
Air Brush Equipment	3rd. Steel									S														S										23
Dictaphones	Main Office		M						M								M								M				M					24
Roofs and Downspouts	Entire Plant														X																			25
Time Clocks	Entire Plant														M																	M		26
Time Clocks	Entire Plant		M						M							M						M						M							27
Double Spindle Shapers	Entire Plant														W																			28
Gates, on Elevators & Tramways	Entire Plant			W							W							W				W				W								29

~SYMBOLS~	
Master Mechanic	X
Ass't. Master Mechanic	X
Engineer Old Power House	O
Engineer New Power House	N
Electrician	E
Steam Fitter	S
Millwright	W
Machinist	M
Machinist Apprentice	M
Belt Repair Man	B

Note:- The numbers in the column under "Duties" refer to a particular paragraph in the accompanying list of Instructions

23 Examine general conditions and have needed repairs made at once. These devices must be kept in the best of condition and no time must be lost in putting apparatus in good working shape. The productive capacity demands it.

24 Examine all dictaphones, oil same, wipe all parts clean. See that cylinder-shaving machine in basement is in working order.

25 Make inspection of all roofs and report to master mechanic.

26 Reset time clocks for dates.

27 Wind time clocks and set same. Report trouble.

28 Have an order entered in master mechanic's office and quarter-turn bearings on double-spindle shapers; location: .....

29 Examine all gates on elevators and tramways. See that gates are free in their slides and ropes in good condition.

NOTE: When inspection discloses apparatus out of order it must be reported to Mechanical Superintendent's office at once; the person making such report can prove himself blameless only by personally witnessing the making out of a Maintenance Shop Order for execution of work reported. In case the date indicated falls on Sunday or a holiday, the work must be performed on previous day. The yellow Inspection Record located at the machine must show your signature and date in order to prove that you or your substitute executed the work as above. These Inspection Records must be hung in conspicuous locations and kept up to date. Remember that your work is watched by officials at the Inspection Record.

MECHANICAL SUPERINTENDENT.

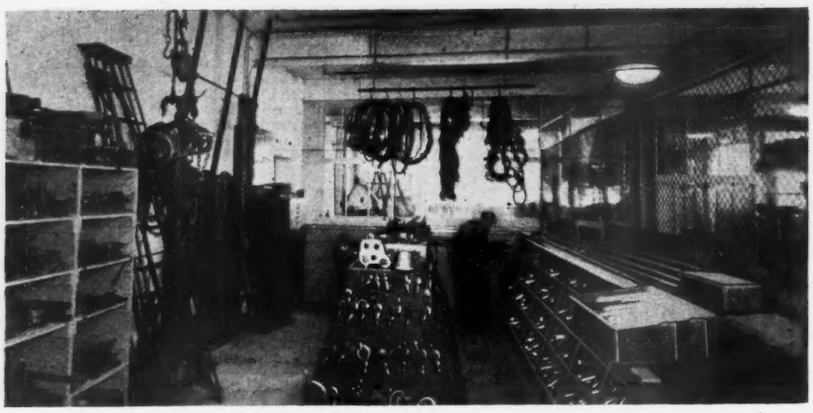
by the inspector as shown by his time card. Nothing can be saved by using a low-grade inspector. The best machinist in the entire plant makes the inspections on the higher-grade and more complicated machinery. We are engaged in the production of wood and steel furniture for printers, dentists, and drafting rooms and so have a number of large woodworking and metalworking machines which we cannot afford to take out of service for expensive repairs, in view of the consequent interruption of production.

When this plan was first inaugurated, our Mechanical Superintendent prepared a detailed Inspection Chart with instructions on the inspection of each type of equipment. When first installed, the men frequently consulted the chart, but as they soon became familiar with it, they had little occasion to use it. In a plant like this, which is the main industrial establishment of a small town, the personnel does not change nearly as much as in many other plants.

Under present conditions, this chart would require a very thorough revision because of the recent growth of the plant and the extensive rearrangement of the equipment which has taken place during the past summer. The Inspection Chart and the Instructions, which are reproduced here, are taken from one of the early charts and are considerably out of date, particularly as to the location of the machines and in some cases as to the time between the inspections. However, the same principles and methods shown here are still followed. Probably no other plant could copy this chart as it is and expect to use it without modifying it to fit particular needs.

This inspection routing had immediate results in decreased repair costs and in keeping the equipment in condition. However, I believe that every line of industrial activity should be closely co-ordinated with the cost and will benefit by having the foremen know the cost of everything for which they are responsible, particularly those items which are indirect expenses, such as maintenance and repair, miscellaneous supplies, and so on. To this end, we added, to the inspection routine, a maintenance and repair cost record and method of distributing these costs to our foremen. Shortly after the end of the month, each foreman receives an itemized statement of all such expenses for his department for the previous month. This report is discussed both in private, if desired, and in the general meetings, which I will cover later.

All orders for any maintenance repairs are made out on the Maintenance Shop Order shown in *A* in



A view of the stock- and toolroom taken from the foreman's office.

This room is in the center of the side wall of the building and contains not only the tools for the machine shop, but also ladders, hoists, cables, portable electric tools and other misceellaneous equipment used by millwrights and repair men. All equipment or supplies are issued on tool check or requisition.

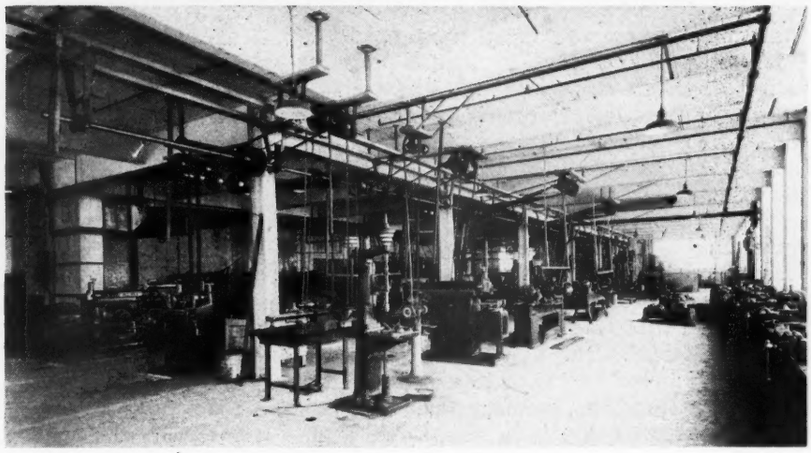
the accompanying set of forms. This order is used for all repairs, alterations and additions to machinery, tools and equipment. The order is issued by the foreman and must be OK'd by the mechanical superintendent and, if for a large amount, by the factory manager. An original and a duplicate are issued on this; the back of the duplicate shows the costs and is returned to the Cost Department when the job is finished.

From the data on this order the mechanical superintendent makes out for each job another order on a manila tag, *B*, which gives the order number and other necessary information to the workmen. When this tag is returned, the mechanical superintendent knows that the job is finished and he can then notify the Cost Department that the job is completed.

Sometimes another department is called upon to do a part of the work, as in the case of repairs to the bearing bracket on the brake press, which was discovered on August 2, as shown by the Inspection Record on page 45. It was decided to weld the casting and so Interdepartmental Order *C* was issued for this welding. If it had been necessary to purchase a new casting, an Order for the Purchasing Department, *D*, would have been issued. Miscella-

The five record forms used in handling maintenance work.

Whenever any alterations or repairs are to be made, on tools or equipment, the foreman issues a requisition on the Maintenance Shop Order *A*. The triplicate goes to the Cost Department and all material and work charged against this order number are entered on the back. When this Maintenance Shop Order is received, the Mechanical Department fills out the Work Tag *B*, which is given to the repair man, who returns it to the office when the job is finished. The Mechanical Department then informs the Cost Department that the job is completed. Occasionally, it is necessary to have some work performed by one or the other production departments and then an Interdepartmental Order, *C*, is filled out, as for this welding job. Where material must be purchased for a job an Order on Purchasing Department, *D*, is issued. Materials are drawn from stores by the Store Room Requisition, *E*. The job order number against which all these materials and labor are to be charged enables the Cost Department to figure the cost of each job, and an itemized report of these are given to the foreman of each department monthly.



A view of the Mechanical Department repair shops.

The maintenance departments have just moved into a new building and occupy the entire end of the first floor. The machine shop is in the foreground, the electrical repair department at the extreme end of the aisle, the blacksmith shop is located in the other corner of the extreme end of the building and the foreman's office and stock- and toolroom located at the center of the right-hand wall. The space between the blacksmith shop and the electrical repair shop is devoted to pipe and conduit fitting and similar work.

neous supplies, needed for repairs or maintenance, are ordered on *E*, the Storeroom Requisition.

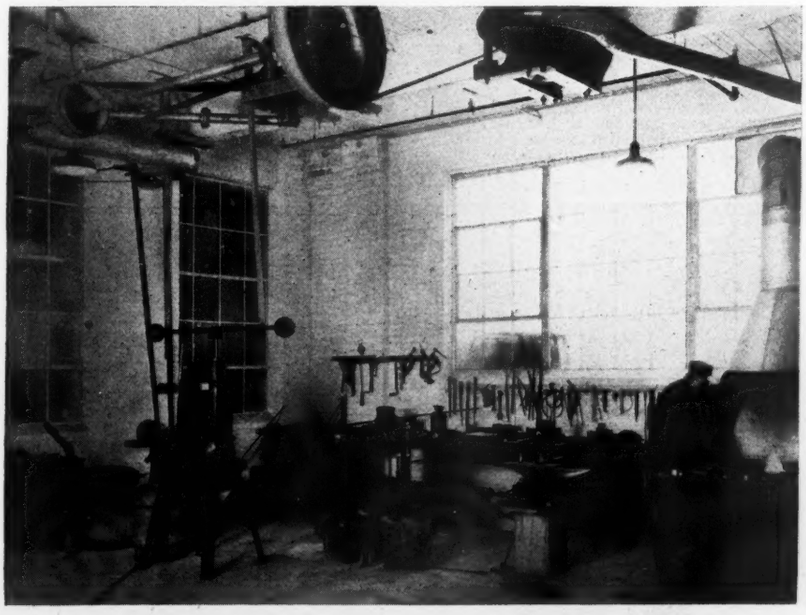
All of these orders carry a job number or some indication to show how the work or supplies are to be charged by the Cost Department. In addition, the monthly itemized list to the foreman reminds him of just what he got; a study of the list indicates ways for him to reduce his departmental costs. He has the Inspection Record against him, however, if he allows needed repairs to go too long and runs up an expensive repair bill. In this way he learns to balance and control his expenditures and costs.

Many interesting cost reductions have resulted from a study of these itemized reports. For example, we had never considered that the use of ball or roller bearings on the lineshafts would be worth our while because the power is all obtained from burning woodwaste and we considered its cost as practically nothing. Under such conditions, what did a few horsepower more or less amount to? However, various foremen began to complain about the high cost of labor and oil for oiling the lineshafts, and point out that ball- or roller-bearing shafthangers would reduce this cost. As a result of our study, we put in SKF ball-bearing hangers, which receive attention only four times a year instead of daily. The savings in labor and lubrication alone are paying for the new hanger bearings.

Another important item is floor repairs. Practically all the buildings have hard maple floors. Most of the wear comes in the trucking aisles, at the doors between departments, and in front of the elevators. The weakest part of the ordinary tongue-and-groove flooring is the upper half of the groove, which splits off as the floor wears. We had been cutting out these worn sections with a portable electric hand saw and renewing them as necessary. Finally one of the men suggested running some maple flooring through one of the machines and removing the tongue and groove before laying in the patch. This worked so well that we endeavored to buy the flooring without the groove and learned of a flooring which is made with a very small triangular projection or tongue on one side and a corresponding small indentation or groove on the other, and we have been using it ever since. As a result, these patches now wear several times as long as they did previously.

To visualize the operating and production costs, we use a number of charts showing the various items of cost, as well as the total, because these can be studied and compared much more easily than can figures. One of these charts, "Comparative Costs of Repairs to Machinery, Transmission and Tools" by departments by months for the year 1925, is reproduced at the head of this article. This chart not only shows the cumulative costs for the year, but also the cumulative average monthly figures from 1918 to 1924, inclusive. Costs for 1920 were omitted from this average because of the abnormal conditions.

This chart is watched closely by all the foremen, and they study carefully the itemized costs to see what items have raised their figure for the month. When a foreman thinks that a repair costs too much, he thrashes it out with the Mechanical Department, which, of course, keeps that department on the alert to see that the items are not so high that they cannot be explained or defended. Also, in several of the departments which have similar equipment, the foremen are direct competitors with each other on low costs. Ordinarily,



One corner of the blacksmith shop.

This contains heat-treating and tempering furnaces, a forge, a grinder, a light hand press, an anvil, benches and a number of miscellaneous tools. In addition, the portable bench vise and stand in the center foreground are often taken to different places in the plant where repairs are necessary.

however, comparisons are made with the cumulative average and the previous average for that particular month, as shown by the chart.

I have made previous reference to the various committees and their part in the control of the shop and the costs. There are six committees in all. The first is a Joint Shop Committee, which is an employee representation organization consisting of seven men elected by the employees and three men appointed by the management. These two groups separately and also jointly discuss general employee and company relations and problems. The Committee acquaints the management with the viewpoint of the employees and in turn conveys to them what the management has in mind.

The next is a Foremen's Committee. This consists of the 30 foremen, the superintendents, assistant superintendents, and the heads of the Mechanical and Power Departments. I preside at this meeting, which is held once a month. All major interdepartmental affairs are discussed and all differences and troubles between the departments taken up and ironed out. It is at this meeting that the cost charts are shown to the men and their explanations of both high and low costs received. This, of course, does not mean that private sessions are never necessary.

Some of the principal problems discussed are: safety, cost per standard hour, cost of defective work, non-productive labor, repair costs, and other costs. Incidentally, the cost of freight and any other item connected with the replacement of any defective work, which may pass the foreman or the inspector, is charged up to the department responsible. When a department is charged with freight to the Coast and back, as one was, it makes that foreman and all the others extra-careful about quality.

In addition, the plans of the company, particularly as to future business prospects, expansion programs, and so on, are discussed with the foremen at these meetings before any public announcements are made, as it makes the foremen feel that they are a part of the company when they know of these plans before the general public hears of them. Confidential matters are also discussed.

These meetings have been held since February, 1920. One example of the results obtained has been the reduction of the reducible overhead (defective work, repairs, store supplies, and so on), which was lowered from 15 cents per man per hour to 9 cents within a year, and to 4½ cents now. This result would hardly have been possible without the itemized expense list which is sent to each foreman, and the monthly foremen's discussion. Without this list, a foreman could not watch his expenses, because he would not know where to direct his attention.

Another example of a saving which has resulted from a study of these items has been the reduction of the benzine consumption in one department from 100 gal. to 20 gal. per day. We had no way of cleaning the dirty benzine, and so the whole tank was emptied each night. The foreman of the department saw that this was one big item of cost, and felt that there should be some way to reduce it. He finally heard of equipment manufactured by S. F. Bowser & Co., Inc., for cleaning and storing benzine. When this equipment was installed the result was a substantial reduction in his costs. The 20 gal. per day represent what might be termed "make-up" benzine.

There are three other smaller committees: Safety, Health and Sanitation, and Fire Protection and Apparatus. The Safety Committee consists of a chairman and three shop men. This committee investigates all accidents immediately after they happen and makes a report. The committee serves 6 mo. and the chairman is a hold-over member of the next committee. This committee also makes an inspection of the plant twice during its 6-mo. term.

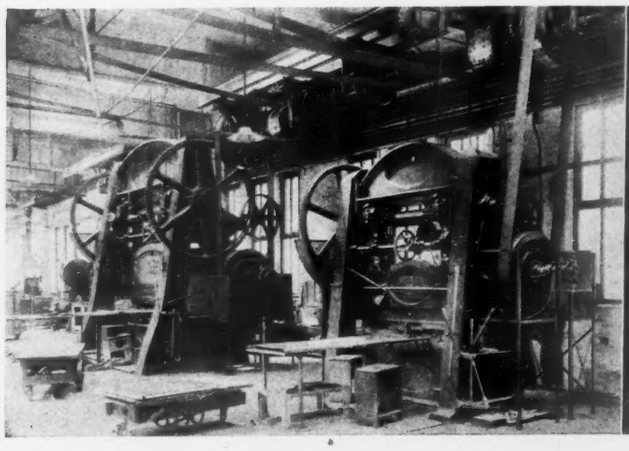
The Health and Sanitation Committee also consists of three men appointed for 6 mo. This committee inspects locker-rooms, washrooms, stairways, toilets, and so on. It also makes two reports during its term. The Committee on Fire Protection and Apparatus inspects all fire apparatus, fireplugs, inspects the hose connections and makes two reports during its 6-mo. term.

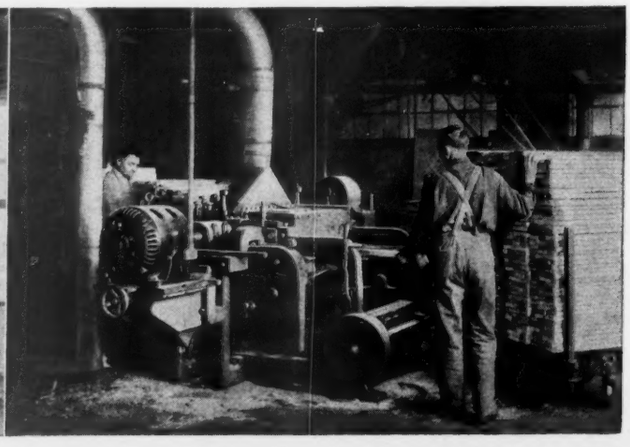
The plan with all of these committees is to rotate the membership and to have as many men serve on them as possible. The chairman in each case is a hold-over member on the next committee, so as to carry forward at least one experienced man on each of them.

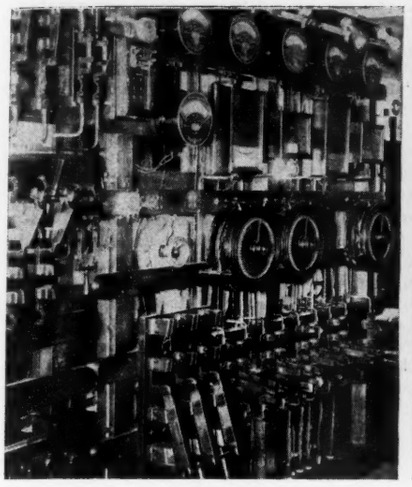
The Manufacturing Board consists of the department heads, the superintendent, the master mechanic, the chief engineer, comptroller, purchasing agent, and secretary. A synopsis of the recommendations made in the reports from all other Committees is received by this Board. This is the controlling committee of manufacturing operations, establishes manufacturing policies, and makes recommendations to the Board of Directors.

Two typical machine installations in the plant of the Hamilton Manufacturing Company.

This plant is engaged in the manufacture of both wood and metal printers', dentists' and drafting room furniture. It is the careful inspection of such machines as this that not only keeps the cost of repairs and maintenance down, but also adds to the safety of the workers. The inspector exercises particular care to detect hot bearings, slipping belts, loose clutches, and reports any other information that the foreman or workman operating the machine should know.







Factors that Determine Necessity for

Replacing Obsolete Equipment

By G. A. VAN BRUNT
Editor, Industrial Engineer

REPLACEMENT of obsolete power drive equipment is one of the important problems with which every industrial operating executive has to contend more or less continuously. When the productive capacity of a plant is being increased, or some of the equipment in use has been destroyed by fire or accident, the problems that are presented are reasonably clear-cut and definite.

These problems resolve themselves largely into a matter of determining what the service requirements are and then selecting the make and type of equipment that will satisfactorily meet these requirements. But what of the equipment that has been in service for some years and is beginning to show signs of the wear and tear that usage inevitably exacts?

The cost of keeping this equipment in service is probably becoming larger each year, as shown by the repair shop records; it needs more frequent inspection and other attention. All of this means that the production delays which can be charged up to it are becoming more frequent, and possibly more costly.

With the proper maintenance attention, including replacement from time to time of such parts as wear out or become damaged beyond repair, it would be possible to keep many items of equipment in service almost indefinitely. The expense and obvious disadvantages of such a course will, however, be apparent at once to every experienced operating executive.

There comes a time in the life of every important piece of equipment when it can no longer be operated profitably in view of the increasing cost of maintenance and repairs, the greater likelihood of breakdown, the lower efficiency, and the lack of desirable operating features possessed by later designs available.

On the other hand, to replace serviceable equipment without adequate justification, is an inexcusable waste of money.

Bearing all of these points in mind, how can the problem of replacing obsolete equipment best be handled? What sort of yardstick, so to speak, can be devised that will enable an operating executive to attack the problem intelligently?

The answers to these questions were sought in the experience of a number of readers of INDUSTRIAL ENGINEER. These men, who are associated with well-known plants in various industries, were asked to tell whether they have a definite schedule for handling replacements, and to enumerate the factors, such as age, trouble from an operating standpoint, excessive repair cost, lower efficiency as compared with new devices, and so on, which they consider to be the most important in determining the advisability or necessity of replacement. They were further asked to discuss the considerations, such as first cost, saving in operating labor, saving in maintenance and repair costs, design and construction (insofar as these affect simplicity and accessibility), and the like, that they regard as important in the selection of new equipment. The answers which these readers have given in the light of their experience, are presented in the following pages.

As a supplement to these accounts manufacturers of some of the more important types of power drive equipment were asked to give their viewpoint on the factors that should be given consideration in determining the advisability of replacement, based on their experience in designing and manufacturing such equipment and watching its performance in the field.

How Replacement of Equipment Is Handled in Seven Industrial Plants

Before major repairs are made to any direct-current motor, E. A. MULVAINE, POWER AND MAINTENANCE ENGINEER, *The Marion Steam Shovel Co., Marion, Ohio, checks the estimated cost of these repairs against the cost of a new alternating-current motor. His policy is to find the most economical way of getting a motor to render a certain service for a given time.*

DUE to the fact that we have very few mechanical drives in our plant, this article will be confined to the replacement of motors.

We do not have any definite schedule arranged for the replacement of a motor or control when the equipment begins to fail. However, when this occurs, we try to locate the cause of the trouble and if it can not be eliminated, we replace the equipment with one suited for the exact conditions. Our principle causes for replacements are overloads, open motors in dirty places, bearing trouble due to bearings not being sealed, and other defects that lead to a breakdown.

All of our d.c. motors operate at 550 volts. When one of these motors fails and requires major repairs, such as rewinding the armature, new field coils, or new commutator, the required repairs are made if the motor is an adjustable-speed motor. Our reason for repairing the adjustable-speed d.c. motor is that we would have to replace this type with an exact duplicate, which would cost considerably more than repairing the old motor.

When a d.c., constant-speed motor fails and requires a major repair it has been our experience that the costs of repairing this motor would be almost as much in some cases as buying a new a.c. motor. When we check up and find the prices about equal or slightly greater than the cost of an a.c. motor, we replace the d.c. motor with a new a.c. induction motor, as we also have available in our plant 440 volts, 3-phase 60-cycle a.c. current.

In case of failure of an a.c. motor, we always determine whether it is cheaper to repair or to buy new equipment. When considering the repair or replacement of a motor the action taken depends on the most economical way of getting a motor to do a certain kind of work for a given time, regardless of whether the motor is repaired or replaced. That is, the cost of repairs are checked against the cost of a new motor. We must also check the life of the repaired motor against the life of the new motor, as well as the additional maintenance cost of the repaired motor against the maintenance cost of a new motor.

In our plant recommendations to replace motors originate in the electrical maintenance department. We keep an accurate record of repairs on our equipment, and the cost of these. We feel this is necessary, and a great aid in he'ping us to determine when any electrical motors or equipment should be replaced, or whether it is being properly taken care of. We believe the following are the most important factors determining the replacement of motors, in the order of their importance: (1) Trouble from an operating standpoint. (2) Excessive maintenance and repair costs. (3) Difficulty in getting repair parts. (4) Low efficiency.

When replacing equipment we do not consider the make of the old apparatus, as we have now standardized on all of our new equipment and any replacements or new items are ordered to the standards, except in the case of some specialties which are made only by some particular company.

In purchasing any equipment the factors considered are listed in the order of their importance. (1) Saving from an operating standpoint. (2) Saving from a maintenance and repair cost standpoint. (3) Design and construction. (4) Cost of equipment.

We have a fairly large plant, operating about a thousand motors ranging in size from ¼-hp. to 750-hp. rating.

First cost is often accorded too much importance in the purchase of new equipment, in the opinion of C. D. CORWIN, WORKS ENGINEER, *L. C. Smith & Corona Typewriters, Inc., Syracuse, N. Y. Before selecting new equipment he compares it carefully with the old apparatus from the standpoint of operating troubles and probable repair costs.*

WE HAVE no definite schedule for replacing obsolete electrical or mechanical power drive equipment in our plant.

Recommendations for such replacement may originate with the millwright foreman or electrical foreman, or with the works engineer. They may also be suggested by the foremen of different departments. In any case, the matter would be investigated at once and the final recommendation would be made by the works engineer. An accurate record of the cost of replacement of all important pieces of equipment is maintained.

In determining replacement, the efficiency of the proposed apparatus as compared with the obsolete apparatus is always investigated for troubles from an operating standpoint as well as repair costs. The problem of the age of the equipment has very little to do with it, if the other items are satisfactory.

In replacing equipment, if the device has been entirely satisfactory and has given as long life as could reasonably be expected, new equipment of the same make would undoubtedly be purchased, but not until similar equipment of different makes had been thoroughly investigated.

When selecting new equipment the writer considers the following factors, listed in the order of their importance: (1) Saving in operating labor. (2) Saving in maintenance and repair costs.

This last item really depends upon the design and construction of the apparatus.

The first cost of the machine is, of course, taken into consideration in arriving at a decision, but the writer believes that too often "First Cost" is permitted to have too much weight.

Equipment should not be replaced at random, merely because it is less efficient than newer devices, in the opinion of H. E. STAFFORD, ELECTRICAL ENGINEER, *Provincial Paper Mills, Ltd., Port Arthur, Ont., Can. He advocates a careful study of conditions, which may show how the efficiency of a drive may be increased by minor alterations.*

THE company with which I am connected has no definite schedule for replacements of either electrical or mechanical drive equipment, such replacements being made when the cost of repairs offset the operating value of the equipment. As all of our equipment is motor driven, it falls to the lot of the electrical department to determine the operating efficiency of the various units.

This is determined by means of load tests, one of which I described fully in an article in the July, 1925, issue of INDUSTRIAL ENGINEER. A load test of the entire plant is made yearly and when any discrepancy in the load is noticed, tests are immediately made to determine definitely the source of the trouble.

If trouble is experienced on a belt drive, for instance, or if belt repair costs are excessive, or power consumption increased due to tightening of the belt in order to reduce slippage, the matter is immediately taken up with the superintendent of that department regarding the advisability of changing to chain or some other drive.

Where improvements can be made in the control of a given motor, as changing from a compensator to a remote-controlled magnetic breaker or starter, the recommendations usually originate in the electrical department. A case in point would be the control of an elevator leg or conveyor where the operator is situated at some distance from the starter.

Recommendations for replacements of electrical equipment, as stated above, originate with the electrical department, while those of a mechanical nature may originate with any of the superintendents, or with the master mechanic.

With both types of equipment an accurate record is kept of not only the major repairs, but minor repairs as well.

The most important factor in determining replacements, from my point of view, is a combination of trouble from operating standpoint and excessive repair cost. If a machine or drive is giving excessive trouble, the repair costs will be excessive in any event. In addition to repair costs, there is also loss of production.

Relegating equipment to the junkpile on account of lowered efficiency and replacing it with more modern equipment should not be done at random. In the first place, a little study of the drive and equipment will often result in increased efficiency by making a few minor changes or sometimes by shifting or substituting one piece of equipment for another.

Whether new equipment for replacement should be of the same make as the old, depends on circumstances. In the first place, greater economy lies in standardization. For instance, suppose an industrial plant has a dozen machines which are identical. It would be poor policy to replace one of these by one of a different make, as double the repair parts would be necessary. On the other hand, if we find a certain machine, drive or control is giving continuous trouble, with the consequent loss in production, it will certainly pay to scrap the unit and install one which can be depended upon.

Saving in operating labor should be the most important factor to consider in purchasing new equipment. The reason for this is that if the useful life of a piece of equipment is ten years and it can be operated by even one operator less, the saving thus made will pay for a large amount of repairs.

Saving in maintenance and repair costs is the second factor in importance, for if equipment requires little or no repairs, it must be well designed and does not necessarily require a great degree of accessibility.

Design and construction are about on a par with first cost; a simple design will require less repair parts than a complicated design, and a good piece of equipment is cheap at any price.

In the selection of new equipment to replace obsolete devices, K. D. HAMILTON, MECHANICAL DEPARTMENT, *Geo. E. Keith Co., Brockton, Mass., considers saving in operating labor to be more important than first cost. Design and construction, in so far as these affect maintenance cost, are next in importance, in his estimation.*

THERE is no definite schedule or basis upon which we replace electrical or mechanical equipment.

Recommendations for replacement originate in the Mechanical Department.

We keep an approximate repair cost on all important machines.

Age is not a deciding factor in the replacing of machinery. If the machinery is in good condition it is kept operating regardless of its age. Trouble from an operating standpoint is a deciding factor in the replacement of equipment. Excessive repair costs are also a deciding factor. Lower efficiency as compared with newer devices and improvements is likewise an important item in determining whether a machine shall be replaced or not.

When replacing equipment we do not always go to the same make, provided new devices are on the market which will improve the operation of the machinery.

In the replacement of machinery we consider the following factors of importance: (1) Saving in operating labor. (2) First cost. (3) Design, as it affects maintenance cost. (4) Construction and accessibility.

Operating troubles, leading to production losses and high maintenance costs, together with improvements embodied in the design of new equipment, are the most important features in determining replacement, according to J. ELMER HOUSLEY, ELECTRICAL ENGINEER, *Aluminum Company of America, Alcoa, Tenn.*

MANY industries having a large power consumption have found it desirable to base their depreciation schedules on the basis sanctioned by the various public utility commissions. This, however, is applicable chiefly to the problems of accounting. It more frequently happens that electrical and mechanical power drive equipment is replaced before depreciation has wiped out the original cost of the equipment. Whenever such equipment is replaced the procedure is co-ordinated between the operating, engineering, executive, and accounting divisions of the company. Such replacements, of course, may well originate anywhere within that circle.

We may enumerate the most important factors in determining replacement, in the order of their relative importance, as follows: (1) Production losses from breakdowns. (2) Advances in engineering design. (3) Excessive maintainence charges. (4) Age of equipment, which is a minor factor. The first two causes are determined from operating and production reports. The third is determined by accurate cost records which are indispensable in the operation of any manufacturing plant. The fourth cause does not need to enter the discussion except as it may appear in one of the first three causes affecting replacement. It may be interesting to follow through this reasoning as applied to one type of equipment, such as the induction motors produced in the year 1910.

About 20 of these motors remained in service up to a short time ago, having been in use for 15 yr. Reports showed that a large percentage of production delays and losses occurred on drives equipped with these motors. Reports of the electrical department showed that the maintenance charges against these motors were more than double those of motors of more modern design. In comparing the design of the old and the new motors it was found that the former had a very small shaft, and that the bearing bushings were short and extremely difficult to line up in the motor endbell. Also, the construction of the rotor bars and end rings was such that the bars would come loose, creating a high-resistance joint which caused a drop in speed of the motor at first, and, later, complete inability to carry any load. In consequence, the entire group of motors of this design was withdrawn from service and replaced with motors of advanced design.

In this particular case all four factors were involved in the replacement of this equipment. The new motors were selected from various manufacturers, as we wished to obtain motors which had the desired mechanical and electrical characteristics in the particular sizes required for the drive to which they were applied.

In generalizing we may say that new electrical or mechanical equipment for replacement should be considered, (1) from the standpoint of its adaptability to operating conditions (nature of plant and materials handled). (2) Low inherent maintenance cost (other than that caused by improper application). (3) Convenience and safety to operators (involving also low operating costs).

Before the purchase of new equipment is recommended, W. E. MULROONEY, CHIEF ELECTRICIAN, *The Carbondale Machine Co., Carbondale, Pa., balances the cost of repairing and maintaining the old equipment against the cost of new apparatus. In selecting new equipment, he chooses only that of the latest and most efficient type.*

NO DEFINITE time schedule is used for replacement of equipment in our plant. Some part of the apparatus, perhaps a motor or starter, may become obsolete due to later and better designs, but if the piece in question still gives adequate service without a great deal of attention we continue its use.

Recommendations covering replacement of apparatus are made by the chief electrician. An accurate record of all repair replacement and maintenance costs are kept by a department in the general office. The chief electrician has access to these costs at all times. Before recommending new equipment several factors are considered and analyzed and the records studied to arrive at a comparison of the over-all cost of maintaining and repairing the old equipment against the cost of new equipment.

If it is decided to purchase new equipment, only the latest and most efficient type is recommended. The age of present equipment is not considered, so long as the piece gives good service. Many of our d.c. motors are over 20 yr. old, but are still giving trouble-free service.

When replacing equipment our policy is to standardize as far as possible, always considering the service

required as well as first cost. This applies particularly to motors. Controls are selected to suit different conditions and may or may not be of the same manufacture as the motors.

When purchasing new equipment the most important factor to be considered is hardly definable. Saving in maintenance cost is, of course, desirable. However, first cost must be considered as well as operating cost. It would seem that if the design and construction is such as to be fairly simple and accessible the maintenance cost will naturally be less. In our case, the purchase of new equipment is considered from all angles, and no one factor predominates. However, from the viewpoint of the Electrical Department, obviously simple design and construction, and accessibility for repairs are very desirable.

An accurate record of the cost of repairs to all important electrical and mechanical power drive equipment is the real basis used by J. S. MURRAY, CHIEF ELECTRICIAN, *Follansbee Brothers Co., Toronto, Ohio, in determining obsolescence of present equipment. When repair costs on a piece of equipment become excessive, it is either scrapped or altered so that it will meet operating requirements with less maintenance expense.*

IN OUR plant a general schedule is followed from which we get some help in determining the proper time to discard obsolete equipment. Recommendations to replace obsolete equipment originate in our department and are approved by the general manager before the work is carried out.

We keep a record of the cost of repairs to important electrical and mechanical power drive equipment, which is the real basis of our decisions regarding obsolescence of equipment. If a piece of equipment is expensive to maintain, we either scrap it or modify it so that it will meet our particular conditions at a reasonable maintenance figure.

In determining obsolescence we consider the following factors most important, in the order given: (1) Excessive repair costs, because these usually involve loss of production, also. (2) Trouble in operating the equipment. (3) Lower efficiency of old equipment, other things being equal, particularly because of the savings that are sometimes made in an improved product and decreased manpower.

In replacing equipment we are governed somewhat by standardization. This, together with the consideration mentioned above, determine to a large extent our selection of new equipment.

We consider saving in maintenance and repair costs and simplicity of design and operation most important. We do not give the question of first cost a large amount of consideration, as our main object is quality both as to what we purchase and what we manufacture to sell.

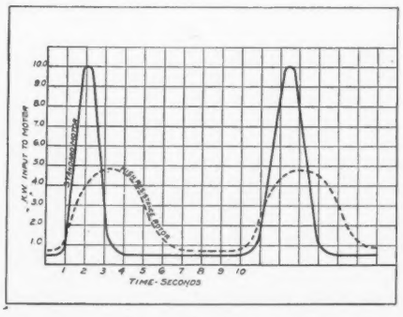
The Manufacturer's Viewpoint on Replacement of Equipment

Motors

In the opinion of A. F. DAVIS, VICE-PRESIDENT, *The Lincoln Electric Company, Cleveland, Ohio, electric motors become obsolete in several respects, among which are changed power requirements of driven machines and advances in motor design; consequently, replacement is frequently justified.*

WHEN electric motors were first installed to drive power machinery, it was believed that the motor would last forever. This belief was substantially correct. By far the greater part of all of the motors which have been built are still in service. The reason for this situation lies in the inherent nature of motor construction, which permits repair or replacement of windings or mechanical parts.

Some motors have become obsolete because it costs more in power to operate them than it would to send them to the scrap pile and install new equipment. It is the general belief that where induction motors can be installed to replace direct-current motors, the reduction in maintenance and increased reliability of operation will justify the capital outlay required. This, of course, is an example of replacement of obsolete equipment. It would be difficult to justify the replacement of constant-speed, direct-current motors in general on the grounds of lower maintenance cost alone, although the maintenance cost of induction motors is certainly less than in the case of direct-current motors. But the reduction of motor failures by the use of induction motors, where possible, results in greater continuity of operation of the motor-driven machinery. Under modern conditions, shutting down essential equipment results in such large losses that very large expenditures are justified for the prevention of such shutdowns.



A properly designed motor used with a flywheel will allow the latter to carry peak loads.

The full line shows the current peaks drawn by standard, squirrel-cage motor with flywheel, when a momentary peak load comes on. The dotted line shows the behavior of a motor with a high-resistance rotor under the same conditions.

Replacement of induction motors on the ground that they are obsolete is justifiable in some cases. The rotor design of early induction motors was poor, with the result that open-circuited rotors were frequently found. It pays to replace such motors with those that have modern welded, cast or solid rotor construction.

By far the greatest number of induction motors which may justifiably be replaced are those which have been misapplied, through poor engineering. Such motors should be put into the second-hand dealer's stock where they can be sent out to drive loads to which they are properly applicable. The most flagrant example of poor engineering in motor application is overmotoring. There are thousands of motors in operation today on which the maximum load never exceeds 30 per cent of the nameplate rating of the motor. Replacement of such motors with smaller ones is economically justifiable, due to the increase in both power factor and efficiency that will result.

The effects of poor engineering in early motor application work are apparent in other ways besides overmotoring. An example of this is the use of a standard squirrel-cage motor for driving a punchpress or other machine that takes the energy for the power stroke from a flywheel, where it has been stored by the motor. The standard motor, owing to its characteristics, will bring the flywheel back to full speed after the power stroke in a fraction of the time allowed for the purpose, with a power draft from the lines of several times the amount actually required.

In this case the proper type motor, which is a squirrel-cage design with a high-resistance rotor, will bring the flywheel back to speed in the full time allotted to the operation, with a correspondingly lower draft on the power lines. This is shown in an accompanying illustration. Replacement of a standard motor by a high-resistance, squirrel-cage motor designed for this purpose, is justifiable because it will result in a substantial reduction in the power bill and an increase in the power factor.

Developments of the past ten years have shown conclusively that slipring motors have been applied in many cases to loads which could have been handled much more economically by the squirrel-cage type of motor which costs about half as much, has a better power factor and, on the average, better efficiency. On these grounds, as well as to secure a reduction in maintenance costs, a good many slipring motors have been justifiably replaced by squirrel-cage motors. Examples of this kind are frequently found in hoists, car pullers, elevators and sim-

ilar equipment where the starting load is very large as compared with the running load.

An interesting question has been raised as to how long it will be before the motors we are installing today will be obsolete. It seems reasonable to suppose that a great many of the structural defects of motors have been corrected in the past 20 years. Substitution of hot-rolled steel for the cast-iron motor frame has resulted in a practically indestructible piece of equipment. We know that we are at the limit of efficiency of the motor as an electrical machine. It seems reasonable to suppose, therefore, that it will take longer for present-day motors to become obsolete than it did for the motors built 10 or 15 years ago. More attention is being paid to the application of motors to the job, so that obsolescence from that source is certainly being materially reduced. Yet it would be the rankest folly to presume that the end of motor engineering is at hand. The induction motor principle has been applied only to rotating devices that we call induction motors; it might be applied to power devices that would bear little resemblance to the present induction motor and yet would effectively serve the purpose of converting electrical energy into mechanical energy.

Motors of modern design possess so many desirable operating characteristics that A. G. AHRENS, MOTOR APPARATUS DEPARTMENT, *Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., considers the replacement of old motors to be justified in many instances.*

NUMEROUS and varied are the reasons that might be set forth for the replacement of motors in industry. And yet, in the final analysis, actual practice in industry demands that any such change in equipment must satisfactorily answer the question, "Does it pay?"

Modern motor equipments offer valuable operating advantages, such as improved speed acceleration, accurate speed regulation, more effective protection against line disturbances, and others. These bring about impressive benefits in the way of increased production, continuous production, lower costs, and better working conditions, which justify changes in motor drives where obsolete equipment is in use. Many examples of such replacements which have worked to the decided advantage of both the industry and the workers, are to be found in the steel, paper, and mining industries.

A very potent fact, and one that should always be in the minds of those contemplating changes in drives, is the question of maintaining a high wage scale, and at the same time reducing manufacturing costs. To do this requires that more efficient processes be developed, and that serious consideration be given to obtaining the most effective and efficient motor drives.

Wear and tear and accidents, are, of course, the most familiar causes for replacement. All of us realize that even the best machinery wears out, and that accidents cause damage. These facts very obviously help to decide the question, "Does it pay," when replacement of motors is being considered.

An important point to remember in ordering motors for replacement, is to make sure that the motors and controllers selected are not only large enough to take care of the existing requirements, but also to take care of the changes that may be made in the future, in order to obtain increased production.

The systemizing and modernizing of shops is important. Given the most effective kind of equipment, if performance records are maintained it is a simple problem to discover where repeated breakdowns are occurring, and prepare for them by keeping on hand a sufficient stock of wearing parts, and those parts most liable to injury by accident. This will prevent many production delays, at a cost that is a comparatively small part of the total investment.

Bearings have been improved so much that N. S. YOST, ELECTRICAL ENGINEER, *Howell Electric Motors Co., Howell, Mich., considers that replacement of sleeve-bearing motors may be justified by the reduction in maintenance cost.*

SO FAR as efficiency, power factor, and the like, are concerned, there should be no reason for scrapping old motors. The copper losses do not increase at all with age, and the iron losses increase only slightly. Practically, however, the deterioration of insulation is so fast in most cases that rewinding is necessary long before the remaining parts of the motor are obsolete. Repeated rewinding tends to destroy the core insulation and to spoil the tooth tips, especially in semi-closed slots, which has the effect of lowering both the efficiency and the power factor.

The greatest improvements in motors during recent years have been made in the bearings, so that scrapping of sleeve-bushed motors may be warranted on account of lower maintenance charges.

Control Equipment

In time the cost of maintenance and repair parts for old control equipment becomes so high, according to W. J. STOCK, INDUSTRIAL CONTROL DEPARTMENT, *General Electric Company, Schenectady, N. Y., that money can be saved by replacing it. In addition, modern control devices offer many opportunities for cutting operating costs.*

THE question of replacing obsolete control devices is one that presents itself to the plant executive from time to time, and may be settled definitely by considering that vital factor in which every executive is interested—cost, both of maintenance and of operation. This cost may show up in a variety of ways and places, and a rather careful consideration of the various conditions is necessary in order to analyze the situation and arrive at a real solution of the problems presented.

The majority of control manufacturers are able to supply repair parts over a long period of years after a device has become obsolete. However, the cost of these parts gradually increases until in many cases the cost of renewal parts is almost equal to the cost of a new control of up-to-date design. In addition to the cost of parts, the cost of installation of these parts must also be considered; this will depend upon the condition of the control equipment. Just how high this combined cost must be to justify scrapping the old equipment, depends upon the individual case, although a definite rule may be laid down for guidance.

In applying this rule, however, the fact should not be lost sight of that all control equipments, whether old or new, are subject to wear from usage and a certain repair charge is justified. The amount of this justified charge depends upon the severity of the operating conditions. Obviously, the repair charge on a control equipment that operates 20 times a minute continuously will be higher than that on equipment that operates only once a day.

With the above in mind, it may be said that where the difference between the cost of upkeep on obsolete equipment and the cost of upkeep on new equipment on the same application, over a period of a year, is greater than the interest and depreciation charges on the cost of the new equipment, scrapping of the old control is justified. Due to the increasing cost of repair parts for the obsolete device as it becomes older, it is obvious that this difference will increase from year to year, until eventually the continued use of the old control will represent an actual loss to the user. This presupposes that the operation of the obsolete equipment when repaired is as satisfactory and the resultant production as high as with the new control, although this is rarely the case.

Much consideration should be given to the fact that modern control schemes and devices make possible a much lower operating cost, because of the economies which are effected. For example, the thermal overload relay allows an operator to obtain the maximum amount of work from a motor without any danger of burning it out. Delays due to burned-out motors, and the resultant charge for rewinding, should be eliminated as much as possible, and the use of a correctly adjusted thermal overload relay is one means of doing this.

In many installations the use of push-button control of up-to-date design has eliminated a certain amount of manual labor previously required when an older type of control equipment was used. Until the advent of the full-magnetic synchronous motor starter, it was necessary that an engineer or factory executive be present to start up a synchronous motor. Now, an ordinary laborer can accomplish

this by merely pressing a starting button. There are numberless applications where, by means of magnetic control, including timing relays and limit switches, it is possible for one operator to look after a large number of machines. It is only necessary for him to start the machine at the proper time and the cycle of operation will be automatically carried along by the control. In many cases when space is at a premium, the magnetic control panel may be installed near the ceiling or in an adjoining room where space is available, with only the push button located near the machine and the operator.

All of these factors result in lower operating expense or a high production rate for the same number of operators; in either case a reduction in cost results. Therefore, careful consideration may well be given to the possibility of reducing the cost of operation by replacing old control devices with those of up-to-date design.

Control equipment should be considered as part of the motor, H. L. VAN VALKENBURG, CHIEF ENGINEER, *Industrial Controller Co., Milwaukee, Wis., points out, as it supplies characteristics that are not embodied in the motor design. It is justifiable to replace equipment that does not meet operating requirements.*

THE problem of when to replace controller equipment is more or less governed by the conditions existing in an industrial plant.

The proper understanding of an electric controller requires that it be considered as a part of the motor. The controller should be designed to take care of the functions not incorporated in the motor design, in order to enable the latter to operate under the specified conditions of load.

Every motor has certain inherent characteristics which enable it to adapt itself to some of the conditions encountered in practice. In many cases, however, the motor would be very expensive and also inefficient if it were given the necessary characteristics to prevent it or the driven machine from being injured, during the cycle of operation.

The most prevalent justification for replacing control equipment is that the present installation does not satisfactorily meet the requirements. The old style of controller providing overload protection by means of fuses is being discarded in modern plants for devices giving overload protection by magnetic or thermal relays.

A recent incident that fully justified the replacement of control equipment may prove interesting, as it covers a condition that is encountered daily. A manufacturer of hosiery found it necessary to increase his production without providing additional floor space. This required the rearrangement of all machinery and the discarding of all manually operated controllers, which were replaced with automatic devices that could be located in such a position that they would not occupy any floor space and still be accessible. The adoption of automatic controllers solved the problem.

The life of control equipment should be measured in terms of the value, rather than years, of its service, says G. O. WILMS, CHIEF ENGINEER, *Allen-Bradley Co., Milwaukee, Wis. He considers that it is economy to replace any equipment that does not meet modern operating requirements and conditions.*

IT IS rather difficult to make a definite statement as to the life of motor control equipment, inasmuch as this depends largely on the service conditions. A control that is used only to start a motor several times a day will long outlast equipment that has a severe duty cycle to perform. If wear only were to be considered, some control equipment could, with little care, be made to last almost indefinitely, whereas other similar equipment that is in hard service and is given but little attention will have a limited life.

It seems, therefore, that the length of life of control equipment should be measured on the basis of the service it renders. In this respect control equipment is no different from any other device. A textile machine whose output does not come up to modern standards in both quantity and quality has outlived its usefulness, even though it may still be in good mechanical condition. The same thing holds true for machine tools, and other equipment. However, a machine may also be considered to have outlived its usefulness if the cost of keeping it in operation becomes excessive.

Years ago a simple, hand-operated control would fulfill all requirements; delays in starting, or the necessity of having a skilled man operate the control properly, were not important. Shutdowns due to repairs, or time unnecessarily wasted in machine operation, increase the unit cost of the product and steps should be taken to remedy such conditions, if the producer wants to get his share of business at a price that will insure profits.

Open-type, hand-operated equipment is obsolete and should be replaced, as it is not only dangerous to operate, but is the cause of delays in machine operation, unless the operator is thoroughly familiar with the equipment. A man who is not familiar with its operation is likely to cause an accident or delay, due to his carelessness or his fear of the equipment. A push button, removed from the control and from the machine, can be operated by anyone, no matter how unskilled or careless he may be, and the factor of fear does not enter at all.

Control equipment that is not provided with no-voltage protection is obsolete and may be the cause of serious accidents both to the machine and the operator, due to unexpected starting of the machine after a voltage failure. Even a minor accident may cost many times the price of a modern control equipment.

Motor starting equipment that employs knife switches, particularly where frequent operation is necessary, should be replaced, as such equipment is likely to be dangerous to the operator. Where such equipment is used on machines that are not in continuous operation, operators are inclined to let the motors run idle rather than operate the switch. The cost of the power unnecessarily used would soon pay for push-button-operated starting equipment.

Starting equipment, either manual or automatic, that puts undue strain on the driven machine or causes belt slippage should be replaced. The cost of a broken gear or burned belt may amount to a good deal more than the cost of modern starting equipment that will insure gradual starting of the motor.

Control equipment, either old or new, that is subject to breakdowns, due to age, misapplication, or more severe service than it was designed for, should be replaced.

No doubt our present type of control will be obsolete ten years from now, but we should not regret this, as it will be brought about by such advances in design that the advantages offered will more than pay for new control equipment, as is now the case.

When the cost of maintaining old control equipment exceeds the interest charges and the probable cost of maintaining new equipment, R. G. WIDDOWS, SALES MANAGER, *The Electric Controller & Mfg. Co., Cleveland, Ohio, considers that the old apparatus may justifiably be replaced.*

THERE can be no set rule to determine when control equipment should be replaced. In general, when the cost of maintenance of the old equipment exceeds the interest charges plus the probable maintenance costs on new equipment, the old equipment may be discarded, provided there is money available for new control apparatus. In many plants, however, it is not an easy matter for the operating department to secure appropriations for new equipment, in which case they will struggle along with old apparatus, which may be very expensive to maintain.

By replacing obsolete equipment with new controllers, important economies may in many cases be secured, due to increased production, reduction in delays, saving in power due to shutting down motors and machinery during idle periods if the process is an intermittent one, reduction in fuse expense, and reduced maintenance charges on the motors. These economies can be secured by replacing obsolete, hand-operated starters and controllers with the more modern push-button-operated equipment. Many plants are finding it profitable to install push-button control as rapidly as their hand-operated equipment reaches the point where a major overhauling is needed.

Considerations of safety may in many cases justify the change-over.

Older styles of starting equipment frequently do not incorporate overload and low-voltage protection, and in the case of a.c. starters, phase-failure protection is often lacking. All these protective features can be secured with the modern push-button-operated equipment.

In industries where a fire hazard exists, or where the atmosphere is corrosive, it will oftentimes pay to replace old-style, air-break control equipment with modern, oil-immersed automatic compensators and across-the-line starters, as this equipment practically eliminates the fire hazard on account of its flameproof features, and will withstand corrosive atmospheres without deteriorating.

Rubber Belts

Usually it does not pay to patch a rubber belt more than once, in the opinion of E. J. BLACK, THE DIAMOND RUBBER CO., INC., *Akron, Ohio, in view of the comparatively low cost of such belts.*

INASMUCH as rubber belts are moderate in cost, as compared with some other types, there is not the same degree of economy in patching and repairing them. A good, practical rule is to make but one patch on a belt. That is, if it has previously been found necessary to insert a piece at the point where the fastening occurs, when the ends fail the second time, it is usually better to replace the belt, rather than to spend additional time in making repairs, with the attendant loss of time and production. Sometimes a piece of such a belt can be salvaged for use as a fill-in on some other belt, but often it is more economical to discard it entirely.

There is nothing extravagant in such a course, for when they are properly applied on drives operating at moderate speed, and are protected from lubricating oil, rubber belts will often give from 6 to 10 years, and sometimes even 18 or 20 years of service. In order to secure such service as this, it is necessary to make an individual study of each drive, so that the belting may be of the right type and ply.

Careful attention should also be given at regular intervals to the pulleys and shafting, as a slight misalignment causes the belt to stretch on one side, and materially shortens its life.

Whenever there are frequent replacements of belting on a particular drive, the plant engineer should give that drive careful thought. Perhaps the speed is too low. This puts a great strain on any belt. Or the pulleys may be too small, or too narrow. Either fault will seriously affect the service of any belt. Again the belt may be too heavy for the work. This is the real difficulty in an astonishing number of cases, especially with short belts.

Belt dressing should be used very sparingly, and never where there is much dust. In dusty places the life of the belt may be considerably increased by occasionally cleaning with linseed oil, after which the belt should be allowed to dry over night before using. This treatment obviates the necessity of keeping the belt excessively tight in order to carry its load, and enables it to give better and longer service.

When the operator feels that a dressing of some sort is necessary, castor oil may be used. There are also one or two commercial belt dressings that may be used sparingly, but where the installation is a normal one, and the belt properly applied, there are few cases where a dressing is really needed.

If every factory using rubber belts would make it a rule that, wherever possible, all open-end belts are to be replaced with endless belts as they wear out, a very great saving would result. In the great majority of cases failure occurs at the point where the two ends are joined. The use of endless belts eliminates this trouble, increases the efficiency of the belt, and saves much of the cost of upkeep and repair. In fact, the use of endless belts would produce so great a saving that in many cases it would be worth while to make any necessary changes in equipment, so that endless belts might be used.

Leather Belts

When properly applied and cared for, CLAUDE O. STREETER, MECHANICAL ENGINEER, *Graton & Knight Co., Worcester, Mass., points out, a leather belt will last almost indefinitely. The question of replacement must be decided for each case individually, rather than on the basis of a rule or formula.*

THERE are so many factors influencing the life of leather belts that it is almost impossible to draw any convincing conclusions regarding the service that a belt will give before it has to be replaced.

In one industry conditions may be so severe that five or six years of life are all that can be expected, whereas in another industry a leather belt will last beyond the memory of several generations.

An appraisal will take into consideration a 40 per cent annual depreciation on leather belting, so that in about 15 years the leather belt equipment, insofar as bookkeeping is concerned, is worth approximately nothing.

On the other hand, there is the Centennial belt which has been in operation since 1877 and is still giving satisfactory service. This is only one of myriads of leather belts that are rendering similar service.

Practically, we find that a leather belt that is properly adapted to a drive and given a reasonable amount of attention never actually wears out in the sense that it is absolutely unusable.

True, a wide belt may pass its days of usefulness on its original drive, due to increase of power requirements, accidents, drive rearrangement, and so on, but this is only one stage in its existence. It is then available to be made into narrower belts, and this reworking operation may be carried on, it is safe to say, indefinitely, as no one actually knows the limit.

Determining when a leather belt has passed its days of usefulness in any of the several stages of its life, is simply a matter of applying common sense.

For instance, let us assume that some 20 years ago a leather belt was installed on the main drive of a plant and at the time of installation the belt was properly proportioned to the drive.

Since then the business of this plant has grown, new equipment has been added to take care of this increase, and old equipment has been speeded up to increase production, until one day the old belt begins to complain and it is looked over. We find that it has narrowed down in width and has started to break through in the center.

This condition is alarming and consequently the load is checked up. We find that the belt is carrying 50 to 100 per cent more than its rated capacity, and it is apparent that although this load increase has been gradual, the belt has been carrying the largest part of it for several years. Hence the present condition of the belt is positively dangerous.

Consideration of the overload to which this belt has been subjected will impress anyone with the fact that the leather has been badly strained, and when the belt is more closely examined we find, in addition to the narrowing down and breaks first noted, that the surface is literally filled with cracks of varying size and depth, clearly denoting the strain to which it has been subjected. An examination of the inside ply shows that in many spots the leather is actually charred, due to frictional heat generated by the belt slipping on the pulleys.

It is apparent there is considerably more service in this belt, but when we consider the fact that it has narrowed down from its original width—and even if it had not, it would not be wide enough to handle the increased power requirement—we are forced to conclude that greater width is imperative.

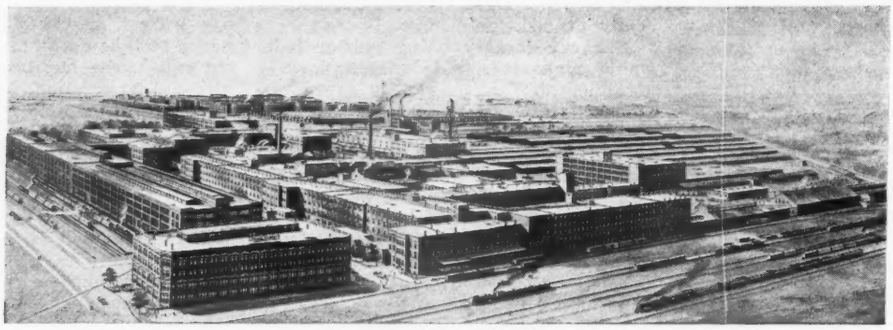
We know that the belt can be worked over and rebuilt to this greater width, but in order to do this the belt must be taken apart, the old glue removed from its several pieces, and the burned and cracked portions cut out. This means a reduction in the thickness of the belt, due to scraping off the old cement, and a shortening of its length from cutting out the damaged stock.

Obviously, new leather must be used to increase the width and maintain the length desired. Part of the resultant belt will then be old, badly-strained leather and the remainder new, live leather. Although the initial investment might be considerably reduced by this practice, the fact, nevertheless remains that we would have a belt of questionable merit and very uncertain characteristics. In other words, it would seem to be more economical to concede that this partciular belt has passed its usefulness in this stage of its existence, and rework it into narrower widths for use in drives where the service is less severe.

ORGANIZED PROCEDURE *in the South Bend Plants of The Studebaker Corporation for the*

Maintenance of Mechanical Equipment and Buildings

FIRST ARTICLE



By IRA De MOSS

General Foreman of Maintenance, Body Division, The Studebaker Corporation, South Bend, Ind.

THE primary object of all industrial plants is to manufacture a product at as low a cost as possible, consistent with the accuracy and quality demanded. The general trend in the automotive industry has been toward increased quality and value in the product at no increase and often at a decrease in price. Much of this has been due to the perfection of machinery and to production in large quantities. Another factor that is no doubt partly responsible is the resultant effect of an increased recognition of the value of adequate maintenance and upkeep to plant, machinery, and equipment.

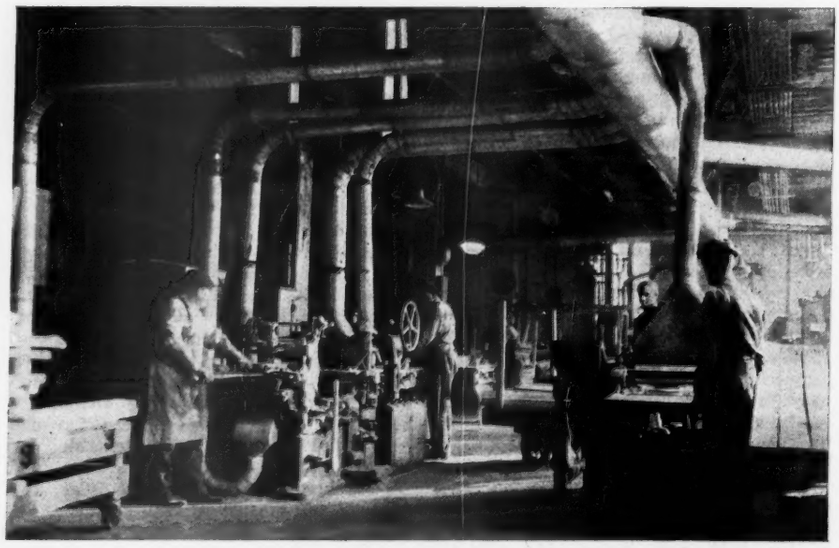
Comparatively few persons outside of the particular industry, however, realize the amount or importance of the auxiliary work necessary to maintain the plant and equipment so that there will be a minimum of necessary interruption, such as periodic overhauling or changing of tools and similar activities which can be planned for, and as few unnecessary or unanticipated interruptions, such as breakdowns, as possible.

Before going further into the description of methods used for taking care of this auxiliary work at The Studebaker Corporation, it may be well to explain first the extent and arrangement of the Studebaker plants at South Bend, Ind. The plants cover a total of 191 acres, not including the proving ground, and comprise a number of buildings with approximately 6,050,108 sq.ft. of floor space.

The Body Division includes a number of large, modern buildings. This plant makes stampings and windshields, and includes all the woodworking and metal-working shops for manufacturing all bodies used on Studebaker cars both in South Bend and in Detroit, and also some of the maintenance repair shops, as will be explained later.

The Chassis Division includes the forge shop, stamping plant, iron foundry, machine shop, and buildings for stores and assembly, final car assembly, car storage, shipping, and power house. The wide variety of operations and types of equipment in the two divisions indicates in a measure the multitude of different problems to be met in the repair and maintenance work.

The routine for handling electrical maintenance and repair work was described in a previous article en-



Two of the machines in the woodworking department of the Maintenance Division.

This woodworking plant is concerned only with the maintenance of buildings and the production of miscellaneous woodworking supplies and devices required in connection with the operation of the plant. Some of the jobs require making only one unit, whereas in other cases hundreds and even thousands are necessary. For example, the 3,000 body trucks used in the building and painting of bodies were all built and are repaired here.

titled "Handling Maintenance and Repairs on 4,000 Motors," which appeared in the February, 1926, issue of INDUSTRIAL ENGINEER; hence this part of the work will not be discussed further here.

Maintenance in the Body Division of The Studebaker Corporation is divided into five departments: machine repairs, millwrighting, woodworking division, body, jig and fixture making and maintenance, and structural and sheet metal. Two of these, the woodworking division and the sheet-metal department, do the necessary work in these lines for both Body and Chassis Divisions; the other departments serve the Body Division only on special occasions. The Chassis Division has a separate machine repair shop and also its own millwrighting, diemaking and maintenance departments.

Because of the large number and special nature of the assembling and cutting dies on body parts, it was considered advisable to have them made and maintained near where they are used, as this would reduce materially the delay and the amount of transportation of these parts. Also, the responsibility would be definitely placed upon the superintendent of the division using them, which is an important advantage when production is so closely tied up with the design, life, and maintenance of these fixtures. The same holds true of machine repairs. The work of these sub-departments will be taken up here in detail.

Machine Repair Shop.—As previously stated, this shop takes care of the Body Division only. The majority of these machines in the Body Division are stamping, forming, and small forging presses, woodworking machinery, and all other equipment incident to body making.

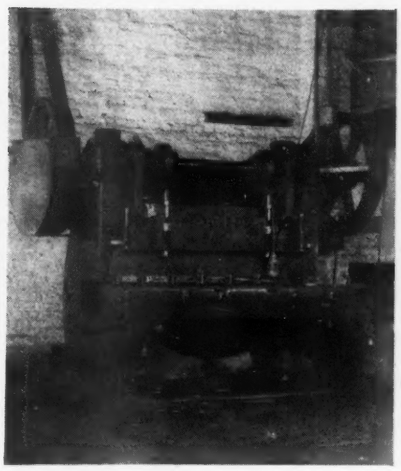


Plate or square shear in the structural division.

This machine will shear ¼-in. plates, 48 in. wide. None of the machines illustrated in this article is used in automobile production.

The machine repair department employs about 46 men under a foreman. Of these, twelve are first-class machinists capable of making a complete new part when desired and of operating any machine in the repair shop. However, most of the men specialize on one or two machines all of the time and the necessary work is passed from one machine tool to the next, as this plan tends to obtain greater output and also does not require as many machine tools. The machines include millers, shapers, planers, lathes, drill presses, and the standard machine tools necessary in a repair shop.

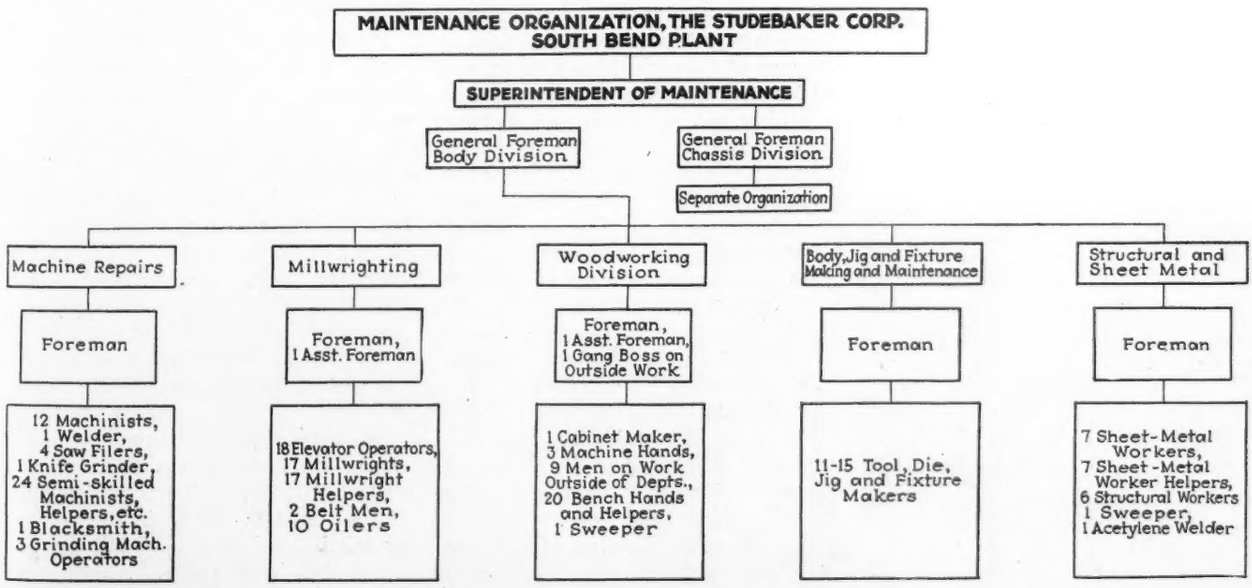
Much of the machine repairs and reconstruction consists of substituting steel for cast-iron parts. Many of these parts are made by building up and forming new parts from flat steel and shapes by means of acetylene welding and cutting torches and then machining them as necessary. One welder is kept busy on machine repairs, although he is sometimes loaned to one of the other maintenance departments. Since all of this work is under the direction of a general foreman it is very easy to shift men from one crew to another.

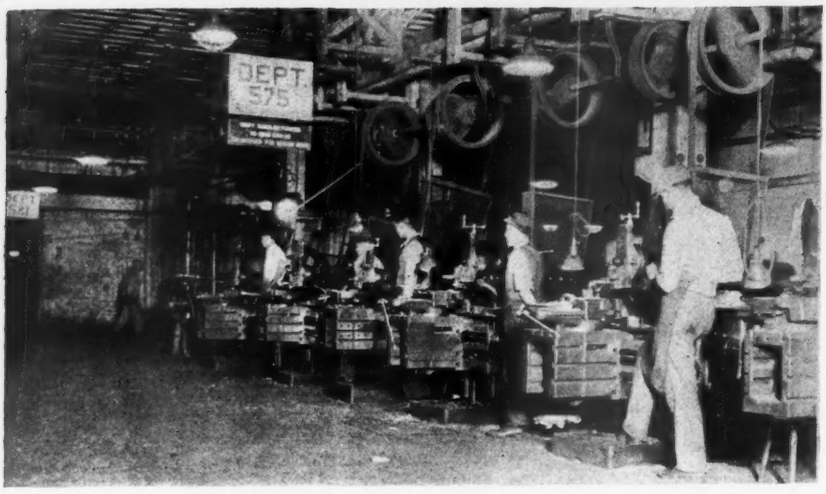
A good man with a torch can bend, build up, weld, cut, and shape up a part to replace many complicated castings much quicker and more economically than patterns and castings can be made, especially for a single part. Also, the substitute is stronger. Time is a very important element to consider in machine repairs, and often it would take too long to send to the manufacturer for duplicate parts. The welders have their oxygen and gas tanks mounted on two-wheeled warehouse-type trucks so that they can be taken to any job. The welder with a helper can handle the truck or it can be fastened to a tractor or trailer and pulled anywhere about the plant.

Gear teeth are built up when broken if the gear is large enough to make it worth while. However, we

Organization chart of the maintenance section work, Body Division.

All of the work done by this department is in connection with the Body Division of the South Bend plant, except the woodworking and sheet metal divisions; these two do the necessary work in their line for all the South Bend plants. The Chassis Division has a similar organization with the exception that it does not have any carpentry or sheet metal division.


MAINTENANCE ORGANIZATION, THE STUDEBAKER CORP. SOUTH BEND PLANT
SUPERINTENDENT OF MAINTENANCE
General Foreman Body Division
General Foreman Chassis Division
Separate Organization
Machine Repairs
Millwrighting
Woodworking Division
Body, Jig and Fixture Making and Maintenance
Structural and Sheet Metal
Foreman
Foreman, 1 Asst. Foreman
Foreman, 1 Asst. Foreman, 1 Gang Boss on Outside Work
Foreman
Foreman
12 Machinists, 1 Welder, 4 Saw Filers, 1 Knife Grinder, 24 Semi-skilled Machinists, Helpers, etc. 1 Blacksmith, 3 Grinding Mach. Operators
18 Elevator Operators, 17 Millwrights, 17 Millwright Helpers, 2 Belt Men, 10 Oilers
1 Cabinet Maker, 3 Machine Hands, 9 Men on Work Outside of Depts., 20 Bench Hands and Helpers, 1 Sweeper
11-15 Tool, Die, Jig and Fixture Makers
7 Sheet-Metal Workers, 7 Sheet-Metal Worker Helpers, 6 Structural Workers 1 Sweeper, 1 Acetylene Welder



One section of the machine and tool repair shop.

All machines of the Body Division are overhauled, repaired, and rebuilt, if necessary, in this department. The repair shop contains a complete machine shop with a large number of bench workers as well as machine hands.

maintain a stock of substitute gears on woodworking and some other machines. These are obtained from the manufacturer and kept in stock. Non-metallic pinions on the motor drives of the woodworking machines have reduced gear wear to a large extent.

To date, an arc-welding unit has not been installed. For work requiring this kind of welding a local contractor is called in. This work consists mostly of locomotive boiler repairs.

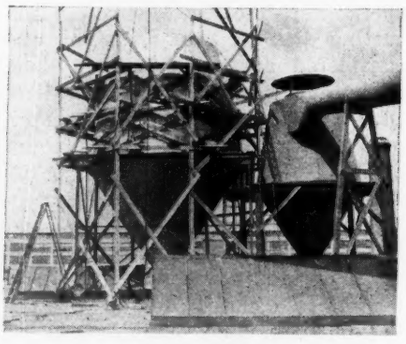
The woodworking department in the Body Division requires a considerable amount of saw filing and knife grinding. This work is taken care of in a separate division of the machine repair shop. Four saw filers and one knife grinder are employed on this work, practically all of which is performed on automatic machines, which must, of course, be set very carefully. The remaining men employed in this department are semi-skilled machinists, bench hands, and helpers.

Another specialized line that is taken care of by the machine repair department is the maintenance of the high-pressure hydraulic system. This consists of one 4-in., double extra-heavy pipe line under a pressure of 2,000 lb. per sq.in., and one 4-in., extra-heavy pipe line under a pressure of 500 lb. per sq.in. During the past five years only three or four joints have let go, a record that may be attributed to the special care and supervision given in connection with their installation. These high-pressure lines are used on the body panel forming presses; the lower pressure is used to close the die, and the higher pressure is then automatically turned on to complete the forming of the parts. The highly satisfactory service of this line is one feature of which this department is very proud.

Millwrighting.—This section takes care of the Body Division only; the Chassis Division has a separate department for its work. This department employs about 65 men, eighteen of whom are elevator operators. Elevator inspection, operation, mechanical repairs, and all the other work of the department are under the direction of the millwright foreman. Electrical work is taken care of by the Electrical Department.

Most of the millwrighting work consists of moving and setting machinery, lineshafts, conveyors, and so on. Plants like this are continually improving their machine layout and arrangement and are making changes in product or additions to the line that necesitates many moves and rearrangements of the equipment. Although this is expensive the economy effected compensates for the extra cost and usually shows a handsome reduction in production cost. This department erects and maintains all the conveyors used in the Body Division.

A large proportion of the machines in the Body Division are individually driven, which decreases the amount of overhead work. Some group drives with lineshafts are used. New lineshafts which are put in are $2\frac{7}{16}$ in. in diameter and usually have ball- or roller-bearing boxes. The type of drive selected in any case depends upon the power required, type of machine, and service. Individual motor drives are especially adaptable to high-speed woodworking machines, and on a number of these frequency changers are used to increase the speed of the motor.



This cyclone is an example of the work done by this department.

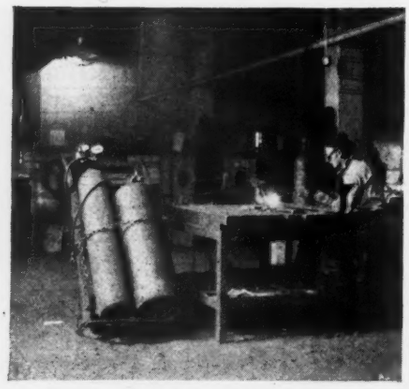
The cyclone was built in the sheet-metal shop and erected by the structural shop. Practically all of the exhaust and duct systems for the plant are built here. This cyclone is 20 ft. in diameter.

Even with individual motor drives much of the machinery is belted to the motor. All leather belts 6 in. or wider are made endless, and practically all woodworking belts are made endless, even in the narrower widths. Other belts are fastened with the pin-and-metal-hinge type of lacing. Practically all woodworking machinery belts are of leather. Some special fabric belts are used on the presses. Rawhide lacings and the pin-and-metal-hinge type of fasteners are used on fabric and special belts. A group of men investigate and recommend types of belts to be used on the different drives and oversee all belt purchases. Two men are employed on belt work in the Body Division.

Our belt men apply, remove, and

One welder is employed steadily on machine repairs.

Many machine repairs are made by building up parts from steel flats or shapes to replace broken castings. When necessary, castings are welded. The welders are shifted around in the departments as necessary. Another welder is employed on structural work.



make up belts as required. The rebuilding and repairing of belting are done by the Byproducts Division, which has full equipment for doing this work. The belt men do no other work than belt work. All oiling done by other than machine operators is by men under the supervision of the millwright foreman employed specifically for that purpose, and they are assigned a definite amount of equipment to care for. This enables them to get fully acquainted with the work and permits of definitely fixing resposibility where failure occurs on account of lack of lubrication. These men do the oiling of all lineshafts, overhead countershafts, and the large machinery, which often have places that are dangerous or difficult of access, particularly the presses; ten men are engaged in this work. The oiling of motors is taken care of by the Electrical Department.

Woodworking Division.—All new construction work and a considerable proportion of the repairs that require high-grade carpentry are taken care of by this department. The Transportation Department also has a carpentry division and its activities will be described in another article by Mr. Sullivan.

The woodworking division has a shop containing a number of individually motor-driven woodworking tools and machines, which are listed in the box on this page, and is prepared to make any parts of wood that may be required in the plant, except parts actually used in the car. This department, in addition, does all repair work on desks, cabinets, and any parts requiring millwork or cabinet work.

The difference between this Woodworking Division and that under Mr. Sullivan may be best explained by an illustration. In case a new doorway is to be cut through a wall the masons would cut the hole in the wall, and the Woodworking Division would make the door frame and door and hang it. In case the door was knocked off its hinges and had to be rehung, carpenters or handy men from the Transportation Department would be called upon. However, if the door were damaged so that machine work must be used in its repair, it would come back to the Woodworking Division.

A large amount of the work of this department is in connection with the construction of the necessary bins, shelves, racks, benches, furniture, cabinets, special stands, trucks, and special work around the plant. One big job going through the department now consists of the remodeling of 3,000 trucks on which the bodies are built and go through the painting department. All of the special trucks or racks for holding or handling any of the parts throughout the factory are built in this department. A slight change in style or model of car often requires extensive alterations in the trucks or racks.

Woodworking Tools in Maintenance Shop

1 Swing saw
1 Rip saw
2 Variety saws
2 Band saws
1 12-in. Jointer
1 24-in. Jointer
1 24-in. Single-surface planer
1 4x9-in. Molder
2 Vertical single-spindle borers
1 Horizontal single-spindle borer
1 Hollow chisel mortiser
1 Radial drill
1 Drill press, 20 in.
Portable electric drills
1 Electric glue pot

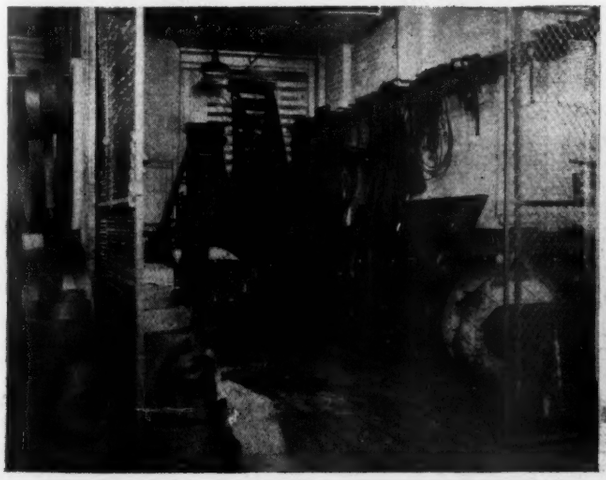
Much of the woodwork turned out does not require finishing. That which does is usually stained and shellacked, or given two coats of oil. On small jobs we do this ourselves. Whenever anything is made in large quantities, we endeavor to make arrangements with the Carpenter Department to paint the parts with a spray gun. The Woodworking Division employs about 36 men. Of these, eight perform work outside the woodshop and three are machine hands. One man is a high-grade cabinet maker and the remainder are bench hands and helpers. The shop is under the supervision of a foreman.

Body Jig and Fixture Making and Maintenance.—This department takes care of the construction of all jigs and fixtures, as well as the small dies on all body construction. Whenever a new body design is brought out, it requires changes or newly built dies for many of the body parts. This department requires, in addition to its foremen, from eleven to fifteen high-grade diemakers and machinists.

Structural and Sheet-Metal Department.—The work of this department consists in doing any structural work or sheet-metal work required for both Body and Chassis Divisions. Small structural jobs, particularly those on which it would be difficult to get an outside contractor to give an estimate, are handled, if it is at all possible, by this department. Conveyors and monorails are fabricated in this department and erected

Two views taken in the millwrights' quarters.

The illustration at the left shows the storage facilities for the millwrights. These sections are entirely inclosed, although a portion of the inclosure was removed here while the photograph was taken. This department looks after the belt work as well as the general millwrighting and the lubrication of the shafting and heavier machines. The illustration at the right shows the carts each millwright and his helper have for their tools.



by the structural department and the millwrights in combination.

An acetylene welder is employed in connection with much of the work for bending, cutting, and welding, such as the installation of a conveyor line. Roller conveyors—that is, the rolls and the side pieces—are assembled in the structural shop and the supports cut from angles or flat stock. Sometimes these supports are bolted together; often the length of conveyor is laid out, blocked in position, and the supports welded on, because it is much less expensive and does not require such careful measurements of the parts as when they have to be riveted or bolted together.

The welders are interchanged between the machine repair department, the millwrights, and the structural shop. On big jobs additional welders are sometimes obtained from the Production Department. This is possible because the construction work in the plant must usually be done when the Production Department is not very busy. Approximately ten structural workers are employed in this department. This shop contains shears for both flats and angles, punches, drills, saws, and so on, for cutting or shaping angles or flats.

The sheet-metal department builds and installs all the dust- and shavings-collecting equipment in the plant. One cyclone recently constructed is 20 ft. in diameter. Some of the exhaust ducts are several hundred feet long. Suction and ventilating ducts from paint booths, plating and other vats, tumbling barrels, sandblasts, grinders, and so on, oil pans, drip pans, hoods for machines and all sheet-metal guards for the entire plant are also made and erected by this department. Belt guards are usually made of No. 18 gage, ½-in. mesh, expanded metal on an angle-iron framework. The angle-iron framework is constructed in the structural shop. Heavier belt guards, such as are used underneath a horizontal overhead belt to prevent its flying in case it should come loose, are usually made of No. 13 gage, ¾-in. mesh, expanded metal. Flywheel guards are made from either sheet or expanded metal.

Method of Handling Orders.—Practically all orders handled by any of these five departments are either repairs and renewals work orders or special shop orders. More than 10,000 repairs and renewals work orders were handled last year in the Body Division alone. A repairs or renewals work order is used in connection with a repair, a change in location or the alteration of some auxiliary equipment, such as a duct, conveyor, truck, and so on. The foremen originate these orders, but an order estimated to require an expenditure of more than $25 must have the approval of the general foreman. These repairs and renewals work orders are made out in quadruplicate and the original, duplicate and triplicate are sent to the general foreman for approval. The quadruplicate is held for record. If approved, the original is sent to the department that is to do the work, the duplicate to the Works Accounting Department, and the triplicate goes to the Estimating, Routing and Inspection Department, which orders any special materials required or suggests changes in the proposed design or layout for making a more economical and satisfactory construction, estimates the probable cost, and inspects the finished job when necessary. Minor jobs are handled upon receipt of the foreman's requisition without getting approval; the copies of the order follow the routine, however.

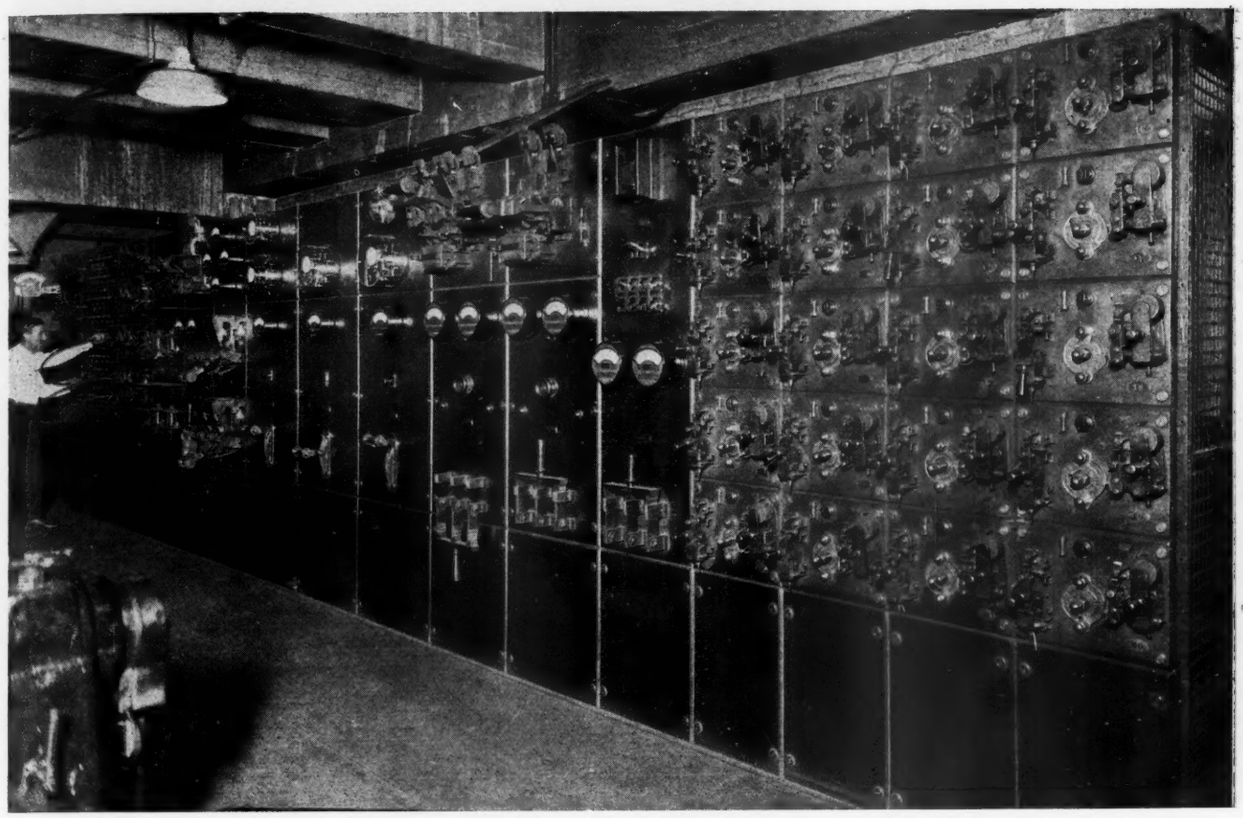
New work of a permanent nature, which would necessarily be entered into the capital account, is ordered on a special shop order. For example, the construction and the installation of a new conveyor or an exhaust duct from a paint spray booth would go on a special shop order. However, in case it were decided to move the booth, the requisition for disconnecting, moving and reconnecting the duct to the booth would go on a repairs and renewals work order. All work orders are given a special number, against which all labor and material are charged and forwarded to the Accounting Department. Materials required from stores are also charged to the same order number.

In all of this work an important point is that it should be carried on so as to interrupt production as little as possible and preferably not at all. In this way many of the changes must be made outside of regular working hours. This is not a desirable condition, but it can hardly be helped in many cases. However, the necessary overtime can be shortened considerably by having everything possible prepared ahead of time and on the job ready for the men.

The second article, dealing with the method of handling plant maintenance, will appear in a subsequent issue.

Bench work in the sheet-metal and structural divisions.

Repairs, alterations and new sheet-metal work are also handled here. The illustration at the left shows part of a duct system under construction. The structural shop, at the right, builds conveyors, structural framework for safeguards and other miscellaneous construction. The sheet-metal and structural shops are in the same room, but across the aisle.



Charging control and switchboard at the Chicago Union Station.

Provision is made for charging 20 truck batteries at a time on the Allen-Bradley modified constant-potential control equipment, which is mounted on the four panels at the right. Another panel, near the operator at the left hand of the board, is used for controlling car-battery charging on trains while standing at the station.

Inspection and Maintenance Routine that keeps

Storage Battery Trucks and Tractors

in service

By W. LANDESS
Chief Electrician, Chicago Union Station Company, Chicago, Ill.

HANDLING of baggage and mail at the Chicago Union Station is performed by a fleet of storage-battery, burden-carrying trucks, tractors and trailers. This is the fifth largest railroad station in the world and serves the Pennsylvania Lines, the Chicago, Burlington & Quincy Railroad, the Chicago & Alton, and the Chicago, Milwaukee & St. Paul. Express is handled under the supervision of the railroads and express company and the equipment used for this purpose is not under the supervision of the station, and so will not be discussed in this article. In addition to handling incoming and outgoing mail and baggage, this fleet also handles mail to and from the mail terminal, which is situated about 1,000 ft. from the ends of the ramps in the baggage room, where all mail has to enter the station from the trains. The connection to the mail terminal is made through a tunnel under the tracks.

Mail and baggage are delivered to and received from the trains on special concrete loading platforms between each pair of tracks. These platforms are 10 ft. 5 in. wide so that trucks or trailer trains can pass, and are constructed without any columns or obstructions of any kind. This baggage and mail platform is raised to a height which makes the platform of the trailers practically on a level with the car door, and so facilitates loading and unloading.

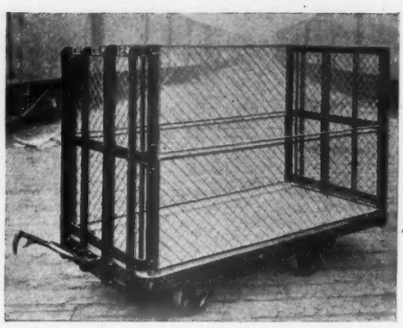
Passengers are received and discharged on another larger and wider platform on the opposite side of the train and between the next adjacent pair of car tracks. That is, there is a baggage and mail or passenger platform placed alternately between each pair of tracks. In this way, passengers and trucking are separated and do not interfere with each other. At the ends of the passengers' platform is a ramp on which they walk up and into the station. The ramps from the baggage and mail platforms extend down into the basement, which is below the tracks.

The trucks and trailers haul the mail or baggage from the end of the ramps in the baggage room either to the mail terminal or to the main baggage room. By using these ramps elevators are not necessary, which saves considerable time in

the operation of the tractors in that they do not have to wait for elevators. Also, it would require a considerably larger number of tractors because only a few trailers could be handled on an elevator at each trip. These ramps are 170 ft. long with a 6¾ per cent grade and are responsible for a large part of the severe service under which the trucks and tractors operate.

The fleet of trucks consists of 12 Elwell-Parker tractors, 8 Mercury tractors, and 8 burden-carrying Elwell-Parker trucks. In addition, 450 Mercury, type A-310 trailers, each with a permanent angle-iron and wire-netting structure erected at the ends, are used for handling mail, and 150 Highway trailers for baggage. Five of these tractors are used, together with the burden-carrying trucks, for baggage and the balance for mail.

Tractors and trailers are used for carrying mail not only because it is a long haul from the terminal to the train, but also a train of trailers permits some separation and sorting of the mailbags according to their destination, such as through or local mail, as received from the train and permits assembling of loaded trailers from different points in the mail terminal, although all the mail on a tractor train is to go on the same mail train. Practically all the mail handled out of the terminal is parcel post.



One of the Mercury, Type 310-A trailers.

These trailers are used for handling mail, generally with the sides removed. The wire-screen and angle-iron structures at the ends are built in permanently. These trailers are greased and overhauled periodically, also.

This fleet is in practically continuous operation. Batteries are changed for charging at the end of each two shifts, 16 hr., or as required. However, in practically one-third of the trucks and tractors batteries are changed at the end of each shift. Except when changing batteries the truck stops only long enough to change drivers at the ends of the other shifts.

The batteries are lifted off the trucks or tractors with a hand chain hoist or a monorail. The hoist is provided with a yoke and chain, especially constructed to hook onto the battery box and place it on a hand lift-truck platform. The charged battery is lifted into position by the hoist and the truck goes back to work. While this is being done a brief inspection is made of the truck, as will be explained later. The batteries are placed in position in the charging stall by a Barrett-Cravens elevating-platform hand lift-truck. At each charging period the battery is inspected for broken cells, and to see if it needs water. Also readings are taken to determine the condition of the battery after use, and periodic readings are taken during the charging period to watch the rate of charge, which also shows the condition of the battery.

The battery equipment includes 38 Exide-Ironclad, 18-cell, 19-plate, 300 amp.-hr. lead batteries for the tractors, and 11 Exide-Ironclad, 18-cell, 13-plate, 204 amp.-hr. lead batteries for the eight burden-carrying trucks. (Additional batteries were on order to be delivered since this was written, for use in the holiday rush.) In addition two Philadelphia Diamond-Grid lead batteries and two Edison storage batteries have been added to carry on a comparison of operating costs, life and service.

Batteries are sent out for any necessary repairs because there is not enough of this work to warrant providing the necessary facilities and keep experienced battery repairmen. Most of the extensive repairs which have been necessary have resulted from an operator driving off the platform. This, incidentally, has also been the cause of most of the necessary extensive rebuilding of

Looking down the ramps from the top of the platform, above, and the lower end of a ramp in the baggage room, below.

An Elwell-Parker tractor and trailers loaded with baggage are coming up the ramp from the baggage-room. The passenger ramp leading into the station is shown on the opposite side of the empty track. Baggage and mail are taken to and from the trains upon this or similar ramps which are 170 ft. long and have a 6¾ per cent grade. It takes about 1 to 1¼ mm. for a tractor to climb this ramp with a load. The platform between the trains is wide enough for trucks to pass and serve two trains. Mail coming from the trains is hauled down on this ramp and over to the left through a 1,000-ft. tunnel to the mail terminal. The door to this ramp is closed and opened by the operator by pulling on the rope, which extends down from the ceiling.

Method of handling mail at the Chicago Union Station.

This train is composed of a Mercury tractor with five trailers loaded with mail. It is interesting to note that no extensive repairs have been necessary either to batteries or to tractors, trailers, or trucks except when the latter have been driven off this platform.

trucks and tractors except one of the old tractors which had been used at the old station and was rebuilt. All truck rebuilding, however, is done in the Station shop.

The batteries are charged at 47½ volts from an Allen-Bradley modified constant-potential charging rheostat with provision for charging 20 batteries at a time. The voltage is regulated by a General Electric counter-emf. voltage regulator.

All current for this Station is purchased from the Commonwealth Edison Company and comes into the substation at 12,000 volts, three-phase, 60 cycles. Here it is stepped down on Station-owned transformers to 440 volts for some of the power service, and to 110 volts for lighting purposes. Also, five 500-kw. rotary converters are used to furnish direct current for elevators, conveyor motors, and fan motors. Direct current for charging electric truck batteries is provided by two Allis-Chalmers 75-hp., 440-volt a.c. and 50-kw., 100/50-volt d.c. motor-generator sets. Another motor generator set and a separate section of the charging board are used for charging batteries on railroad passenger cars while standing at the station before going out on a run.

The charging of the truck batteries is very important because of the heavy load drawn from the battery when going up the ramp. A tractor under load requires from 1 to 1½ min. to make the climb. However, the batteries are standing up very well under this severe service. This is due largely to the thorough and regular inspections and proper charging.

This illustration shows the battery-charging station.

Batteries are removed from the trucks by means of the hand chain hoist shown at the right. These batteries are placed on a platform and handled to and from the charging stalls by a Barrett-Cravens hand-lift, elevating-platform truck. Charging stalls are provided along three walls of the room and, in addition, a second row of charging stations is provided by extending them down from the ceiling about 10 ft. from the side wall. The Elwell-Parker and the Mercury tractors shown are both being charged from this second row. A distilled-water keg is mounted on a special truck at a sufficient height to discharge by gravity into any of the batteries. The still is along the wall, at the right in the illustration. The charging panel and switchboard are on the opposite side of the wall at the left.

At the same time that the battery is changed, the controller and commutator on the motor are given a careful inspection. These are the vital parts of the equipment, as the load imposed when going up the ramp will burn the controller fingers and points, especially if the truck is handled carelessly. If the controller parts were allowed to remain in poor condition, they would rapidly become worse with each trip up the ramp under load. The controllers are of the drum type and are provided with removable fingers and contact points which can be easily and quickly changed.

The commutator is inspected for pitting and cleaned after each 16 hr. of operation. These inspections take only a few minutes; for that matter they can be made while the battery is being changed, and it is believed that they have saved many hours of repair labor and have enabled the trucks and tractors to operate continuously with comparatively few failures on the job.

The men in charge are firm believers in the theory that if they wait too long to repair, they will have considerably more to repair. This is almost obvious in connection with battery, commutator, and controller troubles, but it is just as true of the other parts of the trucks and tractors.

(Please turn to page 82)

Records of Accomplishment

In Reducing Operating and Maintenance Costs and Improving Plant Operation

PLANT operating executives are constantly making changes or devising plans that effect marked savings in operating and maintenance costs, or greatly improve operating conditions. Many of these plans could, with slight modifications, be put into effect in almost any plant. Other plans probably could not be adopted in their entirety, but the general principles involved might be of much assistance to operating executives in different plants who are endeavoring to solve other problems of essentially the same nature.

In order that the details of some successful plans might be recorded for the benefit of others who could make use of them, a prize contest was announced on page 575 of the December, 1926, issue of *Industrial Engineer*. A first prize of $50, a second prize of $25 and a third prize of $15 were offered for the most striking results obtained in reducing operating and maintenance costs and improving operating conditions.

In selecting the prize winners, manuscripts were judged on the general value of the results obtained from the standpoint of the savings made, the improvement in operating conditions, the soundness of the idea, the ingenuity with which it was conceived and executed, and its applicability to other industrial plants.

The first prize was awarded to O. C. Callow, Chief Electrician, Trumbull Cliffs Furnace Co., Warren, Ohio, for the work described in the following article. The manuscripts that won the second and third prizes are published on the succeeding pages.

[First Prize]

Cutting Cost of Operating and Maintaining Lighting Systems

By O. C. CALLOW
Chief Electrician,
Trumbull Cliffs Furnace Co.,
Warren, Ohio

AS THE result of much study on the subject of plant lighting, the benefits of good lighting are now generally understood. This has been brought about largely by the many good papers on the subject that have been published in the technical periodicals and by the literature put out by the manufacturers of lamps and lighting fixtures.

A rather different situation, however, seems to exist regarding the costs of maintaining industrial plant lighting systems. What should it cost per outlet to maintain our lighting equipment? What should be the average life of a lamp in our plants? What is the relation between the number of lamps installed and the number of replacements required per year? These are questions which may be asked of any industrial plant maintenance executive by his superior. But how many can answer this question with any degree of accuracy? There seems to have been very little written on the subject, as was found by the writer when he wished to determine how his lamp costs compared with those in other plants.

Inasmuch as no data were available on this subject it was decided to make a careful study, with the object of cutting down the cost of lamp renewals and securing reliable data which could be used by other industrial plants. It will readily be understood that a direct comparison of the lighting costs of two entirely different types of plants, for example, a coke plant and an automobile factory, would be misleading, but it is felt that by classifying the different types of plants some very useful information could be procured.

The plant in which the figures given later in this article were secured consists of a modern 600-ton blast furnace with power house, boiler house, machine shops, pump house, and ore-handling equipment, and a byproduct coke plant with one battery of 47 ovens, coal- and coke-handling equipment, byproduct department, motor fuel buildings, general offices, and so on.

Available figures showed that for the year 1924, 5,200 lamps had been used, representing a cost of approximately $2,700, which was considered the starting point of our investigations. Our aim was to reduce this figure. A survey was made of each building and the number, type, wattage, and voltage of all lamps used were listed. Orders were issued that all lamps replaced should be carefully charged out to the departments where they were used, and the storeroom was instructed to turn in a report each month to the Electrical Department.

Starting out with these data on hand it was an easy matter to find out just where our heaviest consumption was, and to check these points as improvements were made. Each case of heavy replacements was studied by itself and it was found that practically all of these cases

could be traced to one of the following five causes:

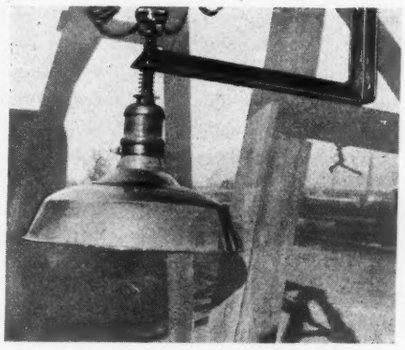
(1) Mechanical breakage
(2) Vibration
(3) Overvoltage
(4) Theft
(5) Continuous burning

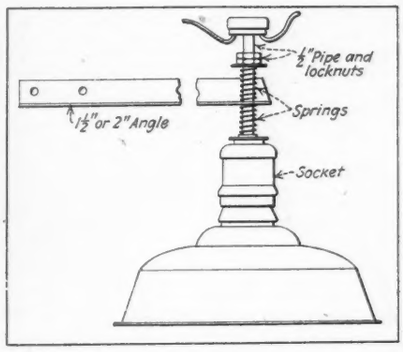
Mechanical Breakage—By mechanical breakage is meant actual breakage of the lamp globe or filament by rough handling or carelessness. Most of this breakage was found to occur to lamps used on extension cords as hand lamps. By equipping all of this class of lamps with a strong, small lamp guard and seeing that no lamps are used without a guard, we were able to effect a distinct saving. The 50-watt, mill-type lamp was standardized for all portable work, as this lamp has been designed as to both globe and filament to withstand rough handling and shocks. Portable lights are used only on the 115-volt circuit, whenever possible, and the use of lamps larger than 50-watt rating is not permitted. We have found it preferable to use two or three extensions in place of one large lamp. This practice also has the advantage of making it necessary to stock only one size of lamp guard for portable lights.

In places where lights have to be mounted in low positions, where there is danger of mechanical breakage, a strong guard is now provided for them.

Vibration—Vibration is probably one of the most important causes of short life of lamps; it is also one of the hardest conditions to remedy, as wherever we have machinery running in a building there is some vibration present. There are two chief forms of vibration which affect lamps: one is experienced on moving machinery such as cranes, ore bridges, and the like, where the vibration takes the form of severe shocks due to stopping and starting the equipment. The other is a steady vibration which may be caused by high-speed machinery mounted in structural steel buildings. Both are very injurious to the filaments of lamps and cause considerable expense for replacement in many plants.

The lower the voltage for which the lamp is designed the stronger we find the filament to be, for a 500-watt lamp designed for 100 volts will have a resistance of 20 ohms, whereas the same sized lamp designed for 250 volts will have a resistance of 125 ohms. For this reason much longer life can be obtained from lamps if they are operated at a low voltage, especially if vibration is present. This is fairly easy to accomplish in building lighting, but in a large number of cases it is impracticable on cranes which are operating on a 250- or 500-volt d.c. circuit. In this case two extra hot rails would be required to pick up the low-voltage circuit. The lamps might be connected in series, using lower voltage lamps, but again we have the disadvantage that if one lamp burns out the one in series with it also goes out, which is sometimes dangerous and always calls for replacement at once. Also, both lamps have to be tested to find the faulty one. The writer has found that series lighting on cranes and ore bridges is not to be recommended.





Here is a simple and effective spring hanger for large lamps.

The simplicity of construction is well shown in the drawing at the right. Old automobile engine valve springs are used to cushion shocks and vibration. The hole in the angle iron or other supporting number should be large enough to allow ample clearance for the ½-in. pipe supporting the lamp and reflector. This hanger is suitable for crane or ore bridge lighting, where the lamps are subjected to considerable vibration and shocks.

In some special cases where three or four lamps of large wattage are sufficient to light the work under a crane, good results have been obtained by using standard, 110-volt lamps with a resistor connected in series with each lamp. These resistors were similar to space heaters and were mounted on the wall of the cab, a separate circuit being run for each lamp. If the resistors are liberally rated their life will be indefinite, and their cost is only about that of the lamp they are used with. Of course, this method is rather wasteful of power, but as a rule this feature is not of so much importance.

The spring hanger, if designed correctly, will also do much to help keep down lamp replacement. There are many of these hangers on the market, some of which will give excellent results. It is suggested that extra-flexible wire be used for connecting up the lamps when using hangers of this type, as we have found that the constant swinging of the fitting will soon break off solid wire, causing grounds.

A very successful hanger has been made up by the writer and used on cranes and other equipment, where there is considerable side swing due to stopping and starting. This hanger is shown herewith and consists of two fairly weak automobile valve springs, which may be obtained from any junk yard, placed above and below the supporting member, which may be a piece of angle or strap iron, or pipe flattened at the end. The lamp socket is fastened to a piece of ½-in. pipe which passes through the supporting piece with plenty of clearance. Adjustment of the spring tension is taken care of by locknuts on the top of the pipe. This hanger was first designed for two lamps on the man trolley of an ore bridge where considerable trouble was experienced; lamps were not lasting 24 hr. After the hangers were installed and 120-volt lamps put in, the first two lamps burned over 1,000 hr.

It is sometimes advisable to keep lamps burning continuously where excessive vibration is encountered, as the filament when hot is more flexible and not so easily broken as when cold. Of course, the useful life or night life of the lamp is reduced, but breakage is cut down and we have found in our experience that an actual saving could be effected in this way.

Overvoltage—Overvoltage is much more detrimental to lamps than is generally realized and for this reason every effort should be made to insure a steady voltage supply for mill lighting. Whenever possible the lighting circuits should be sep-

arated entirely from power circuits. It is best practice to use a separate 110-volt, a.c. lighting circuit which should be connected to the steadiest source of supply available through the necessary transformers.

If the lights are connected to d.c. power circuits from which cranes, hoists and so on are operated, quite a large variation in voltage will be noted. The line voltage may, in fact, go even higher than the voltage at the generator terminals, due to the motors themselves boosting it when, under certain operating conditions, they act as generators.

Table I will be of interest, as showing the effect of overvoltage on the life of lamps.

It will be seen from this table that if we have a lamp designed to operate at 100 volts, and apply 100 volts to its terminals we get the best results, or 100 per cent. If we increase the voltage on this same lamp to 110 volts we will get over 40 per cent more light from it, but we will obtain only one-fourth of its normal life. On the other hand, if we reduce the voltage to 97 we will lose 11 per cent of the light, but increase the life 58 per cent.

The writer is operating his lighting circuits at 115 volts, a.c., but as there is a tendency for it to rise to 118 volts at certain times of the day when the load at the power house is changed, 120-volt lamps are purchased. Since changing from 115-volt to 120-volt lamps, an improvement has been noted in lamp life and this is one of the means used to keep down lamp renewals. It is, therefore, suggested that a recording voltmeter be placed across the lighting circuit feeders and a careful check made of the actual voltage at which the lamps are operating. All new lamps should then be bought to suit this voltage.

Theft—Here again we have a condition which will run up our lamp replacements, and which is difficult to overcome. Theft of lamps is found to be worse in the smaller wattage class, below 100 watts, which, of course, is the cheapest lamp to replace. For this reason if we use a large-sized lamp with suitable reflector, wherever possible, we will eliminate some loss by theft. Furthermore, the manufacturer will, for a very small additional cost, stencil on the lamps, the word STOLEN in large letters; this will prove an effective method of keeping some men from removing them.

A system can be worked out by which only the men in the electrical department are allowed to replace lamps and the old, burned-out lamps must be returned to the stockroom before a new one is issued. The writer has tried locked-on guards and locked sockets, but without very good results. If a man wants a lamp badly enough he may ruin the guard as well as take the lamp, or may break the lamp in trying to force it out of a locked socket. In either case the lamp is lost. Another disadvantage of a locked guard is that the man who changes the lamp may lose his key and in the hurry to get the job done may injure or destroy the guard; whereas if the guard screws on he is sure to have the tools needed to take it off and replace it in the proper manner.

Continuous Burning — This is simply a matter of keeping those lamps turned off which are not required in the daytime, except as stated above, where severe vibration may make it advisable to keep them burning in order to obtain longer life. By correct arrangement of circuits and switches many lights which are now allowed to burn may be switched off in the daytime. Often a whole building is lighted up so that one dark corner may have sufficient illumination. Furthermore, if the windows are kept clean lights which are now needed can oftentimes be switched off. Keeping windows clean is, however, quite a problem in itself.

There is another place where improvement can be made: namely, in danger and signal lamps. The writer has installed a number of signal lights to show when certain motors are running. These lights are controlled by an interlock on the main clapper of the control board and are operated on a 250-volt circuit. It was found that the life of these lamps was very short, owing to continuous operation and varying voltages. As ruby lamps were used the amount of light emitted was of little consequence; therefore, it was decided to place a small resistor tube on each control panel in series with the signal lamp.

This resistor was designed to reduce the voltage on the lamp to 90 volts, and a 50-watt, 120-volt ruby, mill-type lamp was used. Since the voltage on the lamp was reduced 25 per cent, and we have seen from Table I that a 5 per cent reduction of voltage will double the life of the lamp, it can be understood that these lamps now last practically indefinitely. The cost of the resistor tube and labor for installing them was about equal to the price of three lamps, and many more than these were saved in a year on this installation. This arrangement has another advantage: With the 250-volt lamps the operators did not know whether the lamp had gone out due to the motor stopping, or had burned out. This resulted in considerable confusion. Now they know that when a light goes out, it means that the motor has stopped. This system has been used in several places where danger lights are used, as on hot rails and so on, with equally good results.

The results obtained by the changes mentioned above are clearly shown in Table II. Commencing with the year 1924 we find that 1,362 lamps were installed and 5,200 lamps used at a total cost of $2,720, giving a cost of $2 per light per year for replacements, with an average change of once every 96 days. Referring to 1926 we find that 1,456 lamps were installed, and 3,795 lamps used at a total cost of $1,800, giving a cost of $1.24 per light per year, which represents a saving of 38 per cent per light. The average fre-

Table I—Effect of Voltage Variations on Tungsten Filament Lamps

Volts, Per Cent	Candle Power, Per Cent	Total Watts, Per Cent	Watts per Candle, Per Cent	Current, Per Cent	Life, Per Cent
95	83.1	93.2	111.0	97.0	216
96	86.3	93.7	108.7	97.6	185
97	89.6	95.3	106.3	98.2	158
98	93.0	96.9	104.2	98.9	136
99	96.4	98.4	102.0	99.4	117
100	100.0	100.0	100.0	100.0	100
101	103.6	101.6	98.0	100.6	86
102	107.4	103.2	96.1	101.2	74
103	111.2	104.8	94.2	101.8	64
104	115.1	106.4	92.5	102.3	56
105	119.0	108.0	90.8	102.8	49
110	140.3	116.3	82.9	105.7	25

Table II—Results Obtained by Improving Conditions Under Which Lamps Are Operated

Year	115 Volt Lamps					250 Volt Lamps			Special Lamps	Total
1924	50 watt	100 Watt	200 Watt	300 Watt	500 Watt	50 Watt	100 Watt	500 Watt		
Total lamps installed	....	....	....	....	....	....	....	....	....	1,362
Total lamps consumed	....	....	....	....	....	....	....	....	....	5,200
No. changes per year	....	....	....	....	....	....	....	....	....	3.82
Av. life, days	....	....	....	....	....	....	....	....	....	96
Av. life, hours	....	....	....	....	....	....	....	....	....	960
Approx. cost replacements	....	....	....	....	....	....	....	....	....	$2,720
Cost per outlet	....	....	....	....	....	....	....	....	....	$2
1925										
Total lamps installed	356	516	195	64	62	110	43	24	50	1,420
Total lamps consumed	972	1,512	480	196	144	678	168	120	160	4,430
No. changes per year	2.73	2.93	2.46	3.06	2.32	6.16	3.91	5	3.2	3.12
Av. life, days	136	121	147	120	157	59	93	73	120	121
Av. life, hours	1,360	1,210	1,470	1,200	1,570	590	930	730	1,200	1,210
Approx. cost of replacements	....	....	....	....	....	....	....	....	.....	$2,200
Cost per outlet	....	....	....	....	....	....	....	....	.....	$1.54
1926										
Total lamps installed	367	522	210	69	66	95	42	24	61	1,456
Total lamps consumed	960	1,240	342	190	115	564	164	116	104	3,795
No. changes per year	2.60	2.37	1.63	2.75	1.75	5.9	3.9	4.83	1.70	2.61
Av. life, days	140	152	224	132	208	62	93	75	214	140
Av. life, hours	1,400	1,520	2,240	1,320	2,080	620	930	750	2,140	1,400
Approx. cost replacements	....	....	....	....	....	....	....	....	.....	$1,800
Cost per outlet	....	....	....	....	....	....	....	....	.....	$1.24

quency of changing lamps was once every 140 days in 1926.

With the increased number of lamps installed in 1925 and 1926, it will be seen that, assuming the cost per light for replacement at $2 as in 1924, there was a saving of $640 during 1925, and $1,112 in 1926, making a total saving of $1,752 for two years.

The cost of making these improvements has been small, as they were taken care of by the regular maintenance men, and has been offset by the work now saved by the difference in the average number of changes per year, which has increased from every 96 days in 1924 to every 140 days at present.

The number of changes per year is obtained by dividing the number of replacements by the number of lamps installed and this result divided into 365 will show the average life in days for each lamp.

To obtain the average hours' life of the lamps we must know approximately how many hours our lamps burn per day. This can be determined fairly closely by checking those lights which burn continuously, and those which are used only after darkness. If a wattmeter is connected in the lighting feeders so that the power used per year is known the average hours which the lamps burn can be determined by dividing the total wattage of the lamps into the average power consumption per day. Of course, this figure will be only approximate, but it will be close enough for comparison. In our case it was found that the lamps burned an average of 10 hr. per day, and the plant operates continuously 365 days per year.

We found, therefore, that the average life of our lamps in 1926 was 1,400 hr., which brings up the argument that we are burning a number of our lamps after they have passed the point of maximum efficiency, as the lamp manufacturers tell us that the efficient life of a lamp is only 1,000 hr. If, however, power is generated at the plant and a surplus is available the loss in efficiency will not mean very much.

It is interesting to note the average hours' life of the different sizes and types of lamps as shown in Table II. We find that the low-voltage lamps have a much longer life than the 250-volt lamps. The reason for this was explained before: the latter type of lamp is used only on machines where the expense of installing extra hot rails would be prohibitive.

It may be thought that too much time has been spent in saving a few lamps, but it is the writer's opinion that a careful investigation of most plants will show that a considerable amount of money can be saved on lamp replacements. In a large plant it would pay to put a man on this work exclusively, giving him a free hand and a certain figure to work to. The writer has set the cost of lamp replacements for the year 1927 at $1,500, based on the same number of lamps installed as at present, and has every reason to believe that this amount will not be exceeded.

[Second Prize]

Improving Operation of Byproducts Coke Plant

By A. L. BINGHAM*
Ironton, Ohio

ONE of the most difficult problems that confront the operators of a byproduct coke plant is to hold a uniform pressure on the hydraulic gas main. The pressure setting called for ranges from 1 to 5 millimeters of water pressure, but this setting should vary not more than 1 to 2 mm. This is a matter of great importance in securing efficient operation.

Until recently we had in operation in our byproducts plant a type of regulator which was far from being sensitive. It was a motor-driven conglomeration of gears, clutches, magnets and brakes, together with a series of solenoid-operated contactors to energize the magnets which in turn actuated the proper clutch to give the desired direction to the butterfly valve which controlled the pressure. To insure ample lubrication the regulator proper was immersed in a tank of engine oil. The regulator was driven by a ¼-hp., 250-volt, shunt-wound, d.c. motor which ran 24 hr. a day. The motor was connected by a silent chain to a short, ⅝-in. lineshaft in the motor cabinet, which in turn was coupled to the machine proper through a split coupling. Power was then transmitted through a worm gear reduction to the clutches which determined the direction of rotation.

Due to its complicated construction this machine was very unreli-

*Mr. Bingham is Chief Electrician of the plant in which the work described was done. The name of this plant has been withheld at the request of the management.

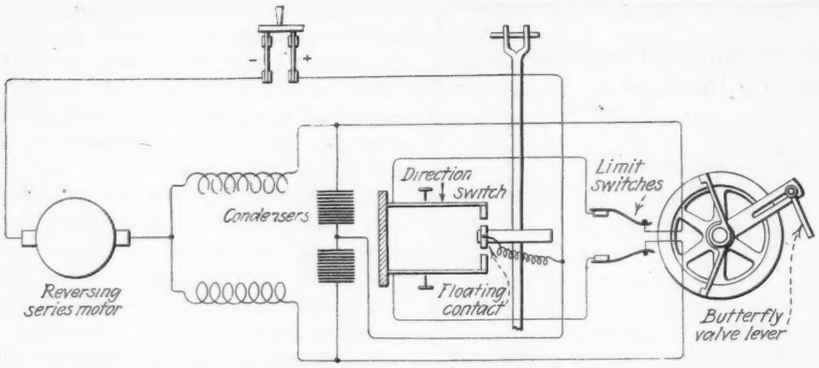


Fig. 1—This shows the method of connecting the motor and control mechanism of the redesigned hydraulic main pressure regulator.

able. It was necessary for the maintenance man to spend from 1 to 3 hr. daily keeping the machine going, in order to maintain a pressure which even then varied 4 or 5 mm. In operation, when it did operate, it was sluggish; perhaps it would open up and not close, causing a suction which created very undesirable operating conditions. Again, the regulator would close and then fail to open, causing an excessive pressure on the block.

Regulation finally became so poor and conditions so bad that inquiries were made of a well-known control manufacturer for prices on three new-type regulators, which were quoted at about $2,500, but with no assurance of perfect regulation.

In view of this, I decided to make the following changes: (1) Remove all magnets, clutches, countershafts, gears and all other unnecessary parts. (2) Make the shaft driving the lever arm worm gear continuous. (3) Make the motor reversible.

The regulator originally had two sets of contacts, each contact being made in two places, together with a set of contacts operating relay coils that closed the main contacts. Thus it was necessary to close three contacts before the magnet coils could operate the clutch lever.

I redesigned the machine to have as few contacts as possible: only one for each direction. Also, it was decided to change the motor to the series type, having two sets of coils, designed much like the motor described by A. C. Roe on page 590 of the December, 1926, issue of INDUSTRIAL ENGINEER.

Fig. 1 shows the connection of the motor and contacts, or direction switch. The motor, which now runs only when the contacts close, was left in its original place and connected in the same manner through a silent chain to the lineshaft. The shaft extends through the cabinet to the compartment where the regulator proper, which is shown in Fig. 2, is installed.

Fig. 2 shows the regulator as it looked after being rebuilt. There was originally a magnet-operated brake at the left end of the shaft, which was replaced by an adjustable, spring-tension brake which is rather sensitive, making it necessary to decrease the tension in cold weather and increase it in hot weather.

The limit switches, shown just above the brake, control the distance which the butterfly valve lever can travel in either direction. These switches were not disturbed other than to make the proper line connections. The conduit clamped to the lever arm was added to support a signal light, which indicates the position of the regulator, day and night; further, this light goes out when the fuses have blown.

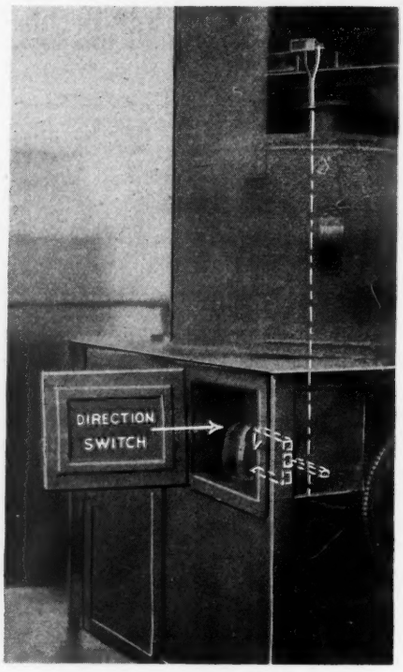
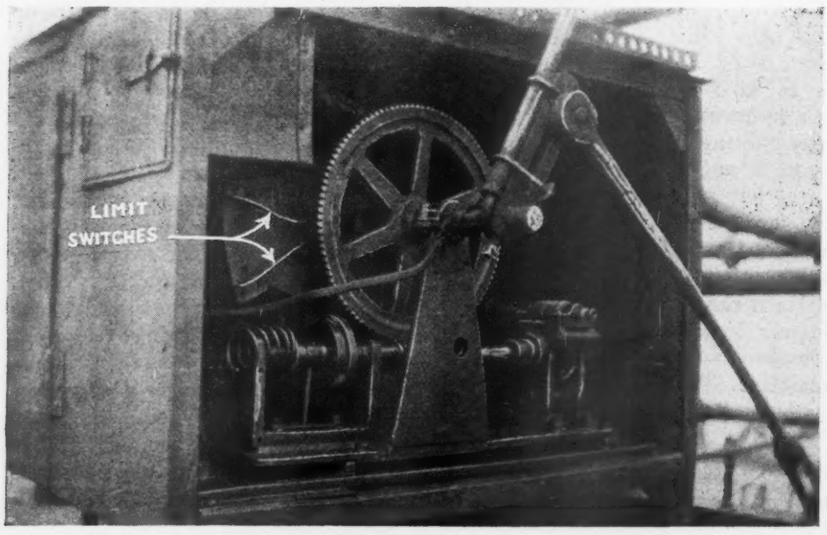


Fig. 3—The direction switch controlling the motor is actuated by the float mechanism.

In order to protect it from the weather, the float machine is enclosed in an iron tank mounted on top of the regulator housing.

Fig. 2—How the pressure regulator looked after it had been redesigned as described in the text.



The direction switch is located in the metal box which can be seen in the upper left-hand corner of Fig. 2 and in Fig. 3. It is a simple device, consisting of two adjustable, platinum-pointed contacts fixed to a fiber base, and a double-platinum-pointed, floating contact which is suspended on a rod leading up into the float mechanism. The latter is placed in a large, round tank for protection from the weather, as shown in Fig. 3.

The condensers used to absorb the current when the contacts are broken

improve operation and greatly increase the life of the contacts.

The time required to make these changes amounted to about 10 hr. for each machine; so the three machines were out of service about 30 hr. The services of one machinist, one electrician and one coil winder were required and the total cost for labor was $42.90, which compares favorably with the quoted price of $2,500 for three new regulators.

These rebuilt pressure regulators have given the following results: (1) Under ordinary conditions, a pressure variation in the hydraulic main of 1.5 to 1 mm. (2) Rapid adjustment to changes in gas flow. (3) Marked dependability. (4) Indication to operators by signal light the instant current is off the regulator. (5) Simplicity and easy adjustment.

Since these regulators have been in operation the plant has raised its coke production over 12 per cent. This has been due chiefly to better heating of the ovens, for good heating is out of the question without good hydraulic main regulation. The yields in byproducts have risen to remarkable figures, as the by-product apparatus has operated more smoothly and efficiently under the more uniform pressure. The physical condition of the coking ovens has improved, as they are no longer subjected to such wide changes in pressure and suction as formerly.

The savings due to increased yields, greater tonnage and lower upkeep, would be difficult to estimate, but there is no question that all of these good things are due in large measure to the better performance of these redesigned regulators.

[Third Prize]

Production Delays Reduced by Eliminating Motor Trouble

By J. ELMER HOUSLEY
Electrical Engineer, Aluminum Company of America, Alcoa, Tenn.

BEFORE me is the card for a 15-hp., 900-r.p.m. induction motor, which has copper rotor bars riveted to a copper end ring on each side of the rotor. It is typical of many other motors on various drives and its record card shows that for some time it made frequent trips to the repair shop; now it is keeping out of the shop and staying out in the plant, where it belongs. What is the story back of this desirable change of behavior?

To consider the problem from the beginning, some of these older motors are, save for the troublesome rotors, just as good and as efficient electrically and mechanically as the newer motors with factory-welded or silver-soldered rotors. However, the trips to the repair shop were expensive. For example, it required ½ hr. for an electrician to go out in the plant and disconnect the motor: cost 30 cents. Two men, a millwright and a helper, unbolted the coupling between the motor and the pump, say, then loaded the motor onto an electric truck and coupled up the new motor: cost $3. There was another charge of $1.50 for the truck and driver, 30 cents to hook the motor up, and 20 cents for oil. By fast work the drive would be out of service only 3 hr. What the production loss may be we will not attempt to estimate, but it is safe to say that it was plenty large enough to be very annoying.

In the shop the motor was dismantled, the rotor bars and rings soldered, in the old days, with half-and-half solder and the motor reassembled at a cost of $15 for labor and materials, without "overhead." The total cost was, say, $20.30. But the repetition is what hurts.

After the motor was back in use and a good overload came on, the poor conductivity of the solder would cause it to become hot and it would be thrown off by centrifugal action. The oxidized surface between the bars and the ring is of high resistance; consequently, the speed of the motor would drop and the pump refuse to deliver the usual output, if any at all. Then the motor would have to be changed again and the whole procedure repeated.

Some time ago we were watching some workmen make repairs to the blading in a steam turbine. The wire shroud through the blade tips was being silver-soldered to the blades by using borax flux and an oxyacetylene torch. It occurred to us that inasmuch as silver is a good conductor, with a high melting point and good mechanical strength, we could eliminate our rotor trouble, if we silver-soldered the bars to the end rings. As this solder contains 70 per cent of silver we recognized the fact that it would be expensive. At the time we found it was 75 cents per troy ounce.

We bought about 25 oz. for experimental purposes and tried it out on a 15-hp. rotor. Our "gas" welder did the job in about 5 hr., the rotor bar and ring surfaces having previously been cleaned, and used 12 oz. of silver solder. In addition to the labor, there was a cost of $9 for silver solder and $2 for the necessary "gas" and oxygen.

The electric repair shop cost remained about the same. The repairmen cleaned the rotor by boiling it in a solution of Oakite Platers Cleaner for about 1 hr., or until the copper was bright, and then rinsed the rotor in hot water. The rotor dried itself in air in a short time. The cleaning tank was about 4 ft. long, 3 ft. wide and 3 ft. deep. It was raised off the floor about 12 in. and was heated by a long gas burner similar to that in a kitchen stove. The entire rotor was immersed in the cleaning solution.

After this rotor was put back in service we had no further trouble with it. Consequently, we found that by adding about 50 per cent to the cost of repairing high-resistance rotors we could end our trouble from that source and, what is more important, eliminate future production delays (which do not add prestige to the electrical organization).

Since starting this method of repairing rotors about 100 have been silver-soldered and not one has failed to perform as well as the factory-welded type. Today several companies are silver-soldering their rotors (one company adopted this practice directly as the result of our experience) at the factory, which is as it should be, for it saves the handling, dismantling and cleaning charges which come if this work is done in the field later.

It is difficult to say just what the savings have been in repair costs and production delays, but we know that they are large.

Fig. 1—This shows the view looking down the center aisle. Equipment to be repaired is delivered from an elevator that is directly behind the point from which this picture was taken. From the elevator the equipment is carried to the point at which work is to be done on it, by hand-operated monorail cranes.

Layout of an Up-to-Date Electric Repair Shop

By H. E. VAN ALSTYNE

Superintendent,
Miller-Seldon Electric Co.,
Detroit, Mich.

TO KEEP abreast of the times, to improve the quality of the service rendered and to utilize every modern method to maintain efficiency have been the policy of the Miller-Seldon Electric Co. ever since it was organized 25 years ago. That this policy has been lived up to is evidenced by the growth of the company since that time. Not so long ago it was necessary to secure larger quarters, and when these were obtained, a repair shop which we believe is a model for layout and for cutting costs of repair work was fitted out.

The general layout of the shop is shown in the floor plan in Fig. 2. All equipment to be repaired comes up the elevator shown at the left. If we assume that we are standing in front of the elevator and looking down a center aisle of the shop, we will have the point of view of the illustration shown in Fig. 1.

Immediately in front of us is the storage space for material awaiting repair. There are runways overhead for hand-operated monorail cranes that will deliver the material undergoing repairs to any part of the shop. The tracks for the monorail cranes are indicated in Fig. 2 by means of dotted lines. The tracks and the five monorail trolleys in use were made by the Louden Machinery Co., Fairfield, Ia. To the trolleys are hung chain hoists for raising the load. One of these can be seen at the left in Fig. 1. This hoist is designed particularly for lifting armatures, there being two hooks, one for each end of the armature shaft. The other chain block and trolley can be seen at the right of Fig. 7.

In general, the location of equipment is as follows:

Starting at the elevators and going down the aisle we first come to the brush making facilities at *1* and *2*, in Fig. 2, and then follow in order the cleaning booths *3* and *4*, stripping benches, dipping and baking equipment, the machine tool section, including lathes, drill-press, babbitting and arc welding equipment, special coil winding section, winding benches and the storeroom. On the other side of the aisle is the small motor repair section, the testing section, the hydraulic press, control repair section, and the coil winding department.

Carbon and graphite slabs suitable for the manufacture of brushes are carried in stock in the storeroom. The slabs are carried in the thicknesses commonly required for brushes; hence it is necessary only to cut them to size, bevel them, and drill the carbon to receive the brush pigtail. The slabs are cut to size in the brush beveling machine located at *2* in Fig. 2. This consists of a tilting table very similar to a tilting saw table. It is made by the

Hub Machine & Tool Co. Instead of a saw, it is equipped with a carborundum wheel which grinds its way through the carbon slab. For brushes $\frac{3}{4}$ in. and more in thickness, a $\frac{1}{4}$-in. thick Acme carborundum wheel obtained from the Green Equipment Co. is used. For brushes less than $\frac{3}{4}$ in., a wheel having a thickness of $\frac{1}{8}$ in. is used. A suction fan is incorporated in the device so that the carbon cuttings are drawn off. There are steel guides on the table so that the brushes may be cut exactly to size. The table can be tilted so as to enable cutting any desired bevel on the bottom of the brushes.

The brushes are then taken to the drill press at *1*, Fig. 2, where they are drilled and countersunk. A hollow rivet is used to fasten the pigtail to the brush. The rivet is fastened by flattening and turning over the headless end by pressure, exerted through a blunt-nosed tool held in the drill chuck while running the drill at a slow speed.

Next to the brush manufacturing section are the cleaning booths. After the motors have been tested to determine what repairs are required, they are cleaned by means of a gasoline spray. The cleaning booths are shown in Fig. 3. As may be seen, they are partially enclosed and are each provided with a suction fan which draws out all gasoline vapor from the cleaning process. These booths are also used for painting the repaired motors.

Each booth is provided with two DeVilbiss spray guns, one of which (the Type A) is used for spraying gasoline while the other is used for painting. A feature of these guns is the fact that the amount of gasoline or paint sprayed is controlled by the operator by the position of the trigger. As a result he can spray as much or as little gasoline as desired depending upon the oil and dirt in the windings. After spraying on sufficient gasoline, by changing the position of the trigger of the gun, the operator automatically cuts off the gasoline and sends out air only; thus he is able to dry out the winding.

Next to the cleaning booths is the dipping room, shown in Fig. 4. There is only one entrance to this room and that is through sliding fireproof doors, which run on inclined tracks and are counterbalanced by weights. On the door end of the lines running to the counterweights is a fire link, which fuses and automatically closes the doors in case of fire. All paints and varnishes that are in cans, which have been unsealed so as to use the contents, as well as kerosene, gasoline, and other inflammable material, is kept in this room.

In the center of the room is a baking varnish tank large enough to accommodate large stators and armatures. The tank is provided with a hinged cover that is counterbalanced by a line and weight. At the cover end of the line is a fire link which will fuse and cause the cover to close in case a fire occurs. The edges of the cover fit into a special oil-filled slot around the top of the tank, thereby sealing the tank and preventing undue evaporation of the varnish. This also eliminates frequent addition of solvent. A monorail crane track runs into this room directly over the tank, as indicated in Fig. 2, so as to facilitate dipping.

In general, all rewound motors are dipped in Berry Bros. No. 500, moisture- and oil-resisting baking varnish and baked for 8 to 10 hr. Transformer coils and other coils that are operated in oil are dipped in Berry Bros. clear baking varnish and then baked. Coils that are to be

Equipment Used in the Repair Shop of the Miller-Seldon Electric Company

1. 10-in. drill press.
2. Tilting table for cutting brushes—made by Hub Machine & Tool Co.
3. Cleaning and painting booths
4. equipped with De Vilbiss type A spray guns.
5. Dipping tank.
6. Baking oven.
7. Sanding wheel.
8. Equipment for babbitting bearings.
9. General Electric, arc-welding
10. equipment; also, oxy-acetylene welding equipment.
11. 18-in. radial drill press.
12. Grinder and buffer.
13. 8-in. lathe for bearing work.
14. 10-in. lathe
15. 12-in. lathe for general machine work.
16. 20-ton hand press.
17. Key seater.
18. Reciprocating power saw for cutting shaft material and structural iron.
19. 30-in. lathe for heavy machine work.
20. 24-in. shaper.
21. Bandsaw for cutting metal.
22. Lathe arranged to wind transformer coils.
23. Segur winding head for winding field and other special coils.
24. Segur tension device.
25. Bandsaw for cutting wood and fiber.
26. Shear for cutting insulation.
27. Dynamometer for testing repaired motors and generators.
28. 150-ton hydraulic press.
29. Browning armature coil winding head.
30. Browning tension device.
31. Browning coil spreader.
32. Electric-Service Supplies Co. taping machines.
33.
34.
35. Armature Coil Equipment Co. coil spreader.

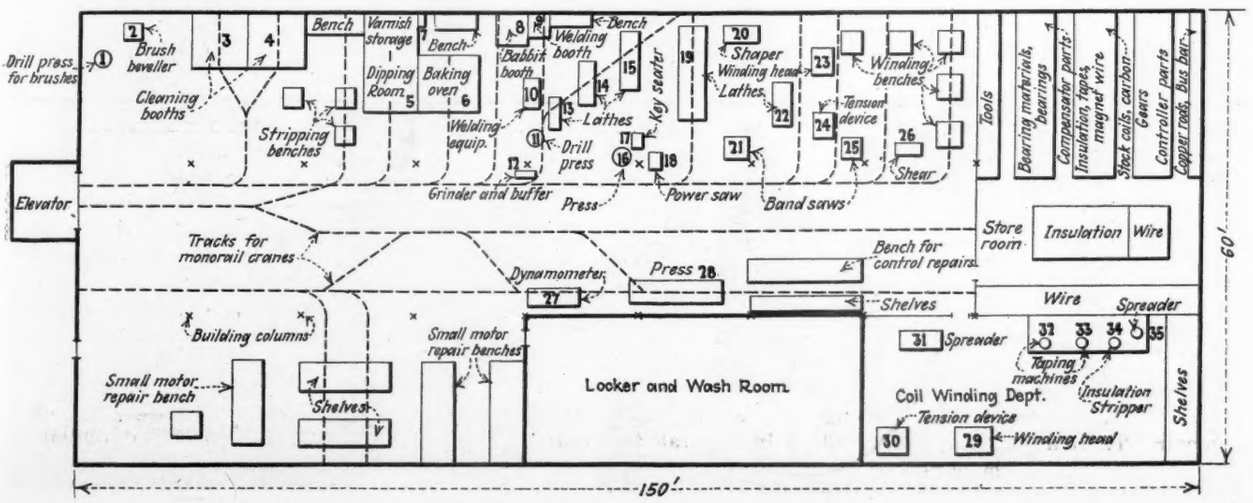


Fig. 2—Floor plan of the electric repair shop, showing the location of all pieces of equipment.

Each piece of equipment is numbered, which numbers are described in the table at the top of this page.

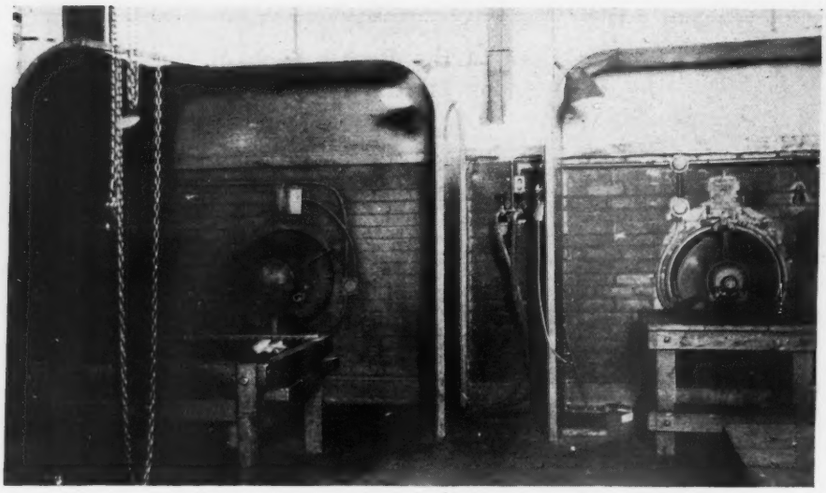


Fig. 3—There are two booths arranged for painting and cleaning.

The booth at the left is especially arranged for cleaning, having a grating on which the dirty apparatus is placed with a drip pan underneath to catch the dirt and gasoline. Between the two booths may be seen the point at which connections are made to the compressed air supply and also the control for the suction fans. Note that each booth has two angle reflectors (one at each corner) so as to give excellent illumination during the cleaning and painting operations.

used in equipment exposed to high temperatures, such as motors around baking ovens, are dipped in Berry Bros. high-heat baking varnish before baking.

All general rewind jobs after being dipped and baked are sprayed in the cleaning booths with Berry Bros. black spirit varnish. This treatment has been very successful in many installations made in chemical works where the motors are exposed to salt and alkali. After the motor has been assembled, the external iron parts are sprayed with an enamel.

Adjacent to the dipping tank is the baking oven shown at *6* in Fig. 2. The baking oven can be seen at the extreme left of Fig. 1. A crane track runs over this oven so that heavy pieces can be readily carried into the oven. The roof of the oven has a slot to permit the crane chains to pass through. This slot is closed by a special cover.

Adjacent to the baking oven is the babbitting booth, as shown at *8* in Fig. 2. This is equipped with large and small pots for melting babbitt for bearings. The booth is covered with a hood which is equipped with a suction fan for drawing off the hot air and fumes from the babbitt pots.

This same hood also extends over the welding booth shown at *9*, Fig. 2. This booth is provided with a curtain to screen the operator from the rest of the shop while making welds. Both gas and arc welding are used, and all manner of welding is done. The carbon arc method is occasionally used for cutting, but usually the oxy-acetylene method is preferred. This method is also used for welding dissimilar metals, brazing, and so on. The arc-method is used for all general welding.

A great deal of arc welding is done on the rotor bars of old motors. For this work Wilson, grade 20, bronze welding wire, 0.120 in. in diameter is used. A welding current of 100 amp. (nearly $2\frac{1}{2}$ times as great as used for steel welding) is required. A long arc (nearly $\frac{1}{2}$ in.) is drawn so as to melt the copper on the rotor before fusing the welding wire. The polarity is reversed at the welding machine so as to be the opposite from that normally used when making steel welds.

This method of welding is used on rotor bars of old rotors that have been bolted, brazed, soldered or riveted, as it is cheaper than some others and gives a permanent job. A copper ring is built up of such size as in our judgment will not materially change the starting characteristics. Rotor welding is illustrated in Fig. 5. After the rotor is welded it is placed in a lathe and the built-up ring is turned smooth. In some instances it has been necessary to make saw cuts at intervals in the end rings to increase the resistance of the rings, so as to give sufficient starting torque. This, however, does not affect the rotor bars in any way.

Adjacent to the babbitting and welding section is located the sec-

Fig. 4—Storage room for inflammable materials such as paints, varnishes, and gasoline.

In the center of this room is the dipping tank with an oil-sealed cover as shown. The monorail crane runs directly over the tank so that heavy pieces may be conveniently dipped and held over the tank to drain.

Fig. 5—Welding the bars on the rotor of an induction motor by means of the electric arc.

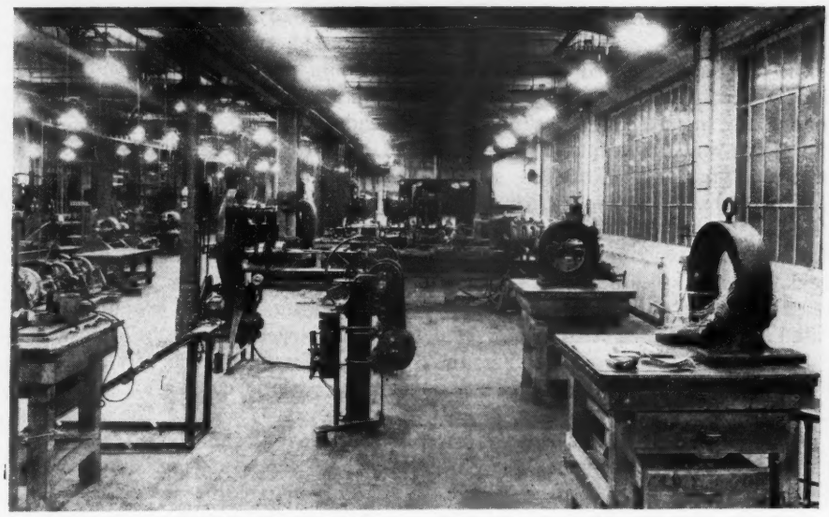


Fig. 6—Here are the winding benches and special coil winding section.

In the center foreground are shown a Segur winding head and tension device that are used for winding field and other special coils. Immediately behind is a lathe specially arranged to wind transformer coils. In the background is the machine tool section of the shop.

tion of the shop in which all machine work is done. From the floor plan layout, shown in Fig. 2, and the accompanying table it will be noted that there are located in this section four lathes, a drillpress, keyseater, slotter, grinder, power saw and two bandsaws.

Just beyond the machine section is some special equipment for winding field coils, transformer coils, and the like. This can be seen in the center foreground of Fig. 6, which is taken from the winding benches, looking towards the machine section. Items *23* and *24* of Fig. 2 are in the center foreground and two of the winding benches are shown at the right. The winding benches take up all of the space between the special coil winding section and the storeroom. The storeroom is equipped with steel shelving which enables storage of a large amount of supplies in a small space. All manner of repair parts are stored here, as will be noted from the list on the floor plan in Fig. 2.

Beginning again at the front end of the shop, the space on the other side of the aisle from the cleaning booths and the dipping room is devoted to small motor repair. The part of this section next to the locker and wash room can be seen in Fig. 7. This illustration was taken at the grinder, *12*, in Fig. 2, looking towards the dynamometer *27*. As can be seen, this section consists mainly of benches which are equipped for working on fractional-horsepower motors.

Adjacent to the small motor section is the dynamometer. This piece of equipment was made up in this shop. It consists of the generator shown at the left in Fig. 7, which is mounted on an extra set of bearings which are attached to the frame of the dynamometer. These two bearings can be clearly seen in Fig. 7. This arrangement permits the generator frame to revolve as well as the rotor. A spring scale is attached to the eye bolt of the generator frame and suspended to an upright braced against the floor. The scale and support can be clearly seen directly behind the generator. A lathe chuck is fastened to the generator shaft, thereby permitting quick connection to any motor it is desired to test.

The motor is mounted on the frame at the right-hand end of the dynamometer, as shown in Fig. 7. This frame can be raised or lowered by means of four machine screws, one at each corner. Each of these screws has a chain sprocket in the top end and a drive chain, which can be seen in Fig. 7, connects all four sprockets together. Hence when one screw is raised or lowered, the screws on the other three corners are adjusted a similar amount. Adjustment in a horizontal plane is obtained by means of the two channels on which the motor is bolted. Hence, any size of motor can be quickly lined up to the chuck on the generator shaft.

In using the dynamometer, power is applied to the motor, thereby causing it to operate and turn the generator armature. By closing the field circuit on the generator and applying a weak field, the generator develops a voltage that causes current to flow through resistance shorted across the armature. This action also develops a torque which causes the generator frame to revolve. The scale prevents it from turning, at the same time indicating the pounds torque developed by the generator. By varying the generator field current and the resistance across the armature, any desired torque up to the capacity of the generator can be developed. Hence any desired loading may be put on the

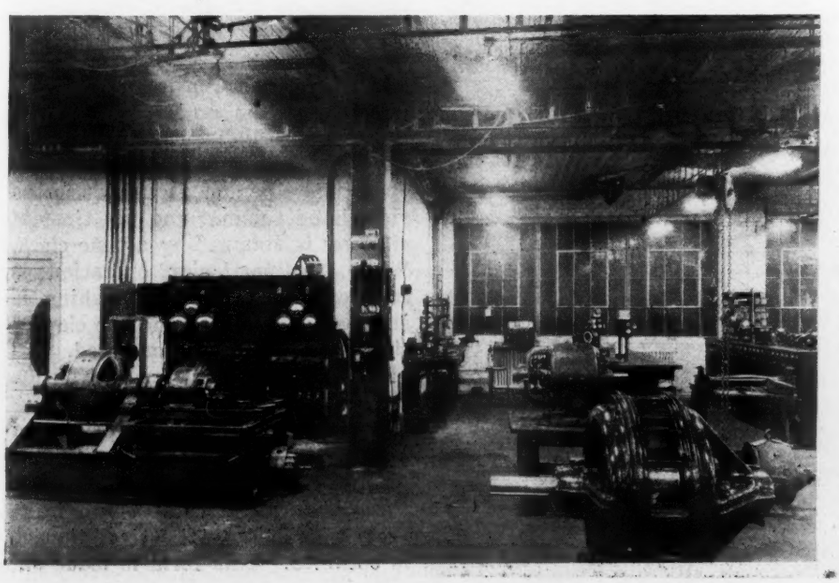


Fig. 7—Testing section and small motor repair part of the shop.

In the left foreground are the dynamometer and switchboard which are used for testing motors after being repaired. On the column in the center foreground is an arrangement of lamps and plugs with extension leads for furnishing voltages up to 2,300 volts for locating faults in motors that are to be repaired. The small motor repair section is shown in the right background.

motor and can be held at a constant value.

On the switchboard behind the dynamometer are mounted instruments for measuring the input to the motor and the output of the generator. The output of the generator is absorbed by a resistance shunted across the armature and is adjusted by varying the generator field current. Readings of the generator output and the weight indicated on the scales are referred to calibration curves from which the horsepower developed is determined directly.

On the column in the center foreground of Fig. 7 is shown one of the test points from which leads are taken to damaged motors to test them for grounds and other insulation failures.

Adjacent to the dynamometer is a 150-ton hydraulic press located at *28* in Fig. 2. This press is unusual in that it is operated by compressed air in setting up the work. This makes for speedy movement of the jack and enables clamping the work in the press by air pressure. The real pressure is applied by oil from a motor-driven pump. All heavy press work is done here, the light work being done on the 20-ton press located at *16*, in Fig. 2.

The control repair section is located next to the hydraulic press. This consists of a bench and a large section of steel shelving immediately behind it, all of which is equipped for aiding the repair of all types of controllers and accessories.

Next to the control repair section is the armature coil winding section. This is equipped with a Browning winding head, tension device, and coil spreader. A view of these machines is shown in Fig. 8. On the long bench adjacent to the storeroom are located two Segur taping machines, an insulation stripper and an Armature Coil Equipment Co. coil spreader.

Daylight is received from large windows on both sides of the building. In addition to this, related kinds of work are grouped together and the work producing dirt and dust is grouped. For instance, the brushmaking section, cleaning, and stripping sections are all close together. They produce dirt and dust and are in one corner of the room. The suction fans in the cleaning booths prevent this dust from going to other parts of the shop. Babbitting and welding produce fumes, so they are located together and provided with a suction system for handling the fumes. All of the machine tools are grouped in one location.

Likewise, the armature coil winding section is located in one corner of the room, which is fenced off by wire screening. Inasmuch as girls do a great deal of this work it affords a separate place for them to work. All of the small motor repair work is grouped together. Also, note the convenience of the dipping room to the baking oven and then back to the cleaning booth for final spraying of black varnish and enamel. Attention is also called to the excellent system of electric lighting as exemplified in Figs. 1, 6, and 7.

It will be interesting to trace the progress of a motor undergoing repair in its travels through the shop. The motor is delivered to the shop floor by means of the elevator. As soon as it is received, it is given the identification card shown at *A* in Fig. 9. A job number is stamped on both the top and bottom halves of this card and the other information called for on the card is filled in. The top half of the card is tied to the motor while the bottom half goes into the office as a record of the motor.

The machine is at once tested at one of the test points (such as the one shown on the column in the center foreground of Fig. 7) to determine what is wrong and what repairs will be needed. These are entered on the bottom half of the card and an estimate of the cost is made. If the customer decides to have the job done an order number is issued and stamped on both halves of the identification tag.

The motor is then taken apart on the stripping benches near the dipping room (as shown in Fig. 2). If the machine must be rewound, the old winding is stripped out at this same place. It is then cleaned at the cleaning booth.

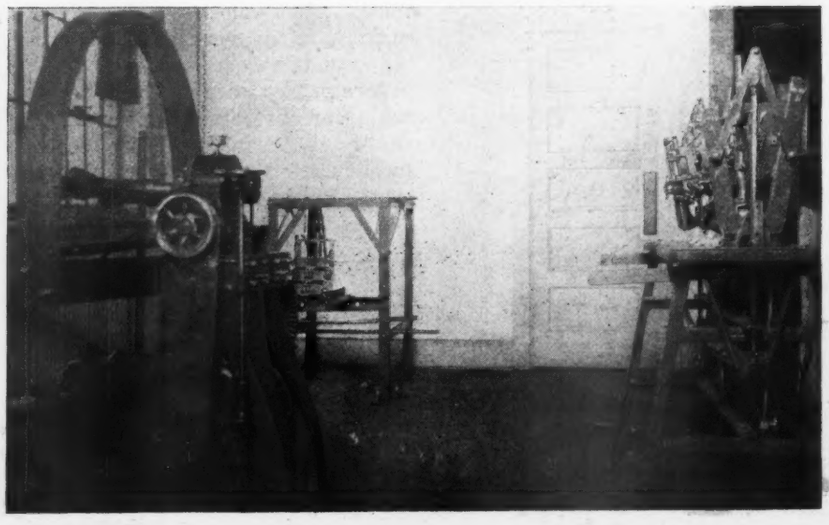
In the meantime, new coils are being made in the coil winding department and any machine work or welding required is done in the corresponding sections.

Before the winding was stripped the coil data were taken and recorded on the form shown at *B* in Fig. 9. On this same card the coil maker records the material used in making up the coils. When the coils have been made they are delivered to the winding benches near *26* in Fig. 2, and card *B* is returned to the office.

The material charged out on card *B* is entered on the form shown at *C* in Fig. 9. Each workman on a given job presents the card shown at *D* to the time clerk, who writes in the workman's name and number; the operation to be done is written in the right-hand column, and the time of starting is stamped by a time clock. When the particular operation is completed, the time of finishing is stamped on the card and the elapsed time can readily be computed. All material that is used for a given job is entered on the form shown at *C* in Fig. 9. The total material cost and the labor cost are consolidated on the "Incoming Motor and Job Record" form shown at *E* in Fig. 9, from which the total cost of the job is obtained. This form is made out

Fig. 8—This illustration shows one end of the coil winding department.

At the left is a Browning armature coil winding head and behind it a tension device made by the same manufacturer. At the right is an armature coil spreader.



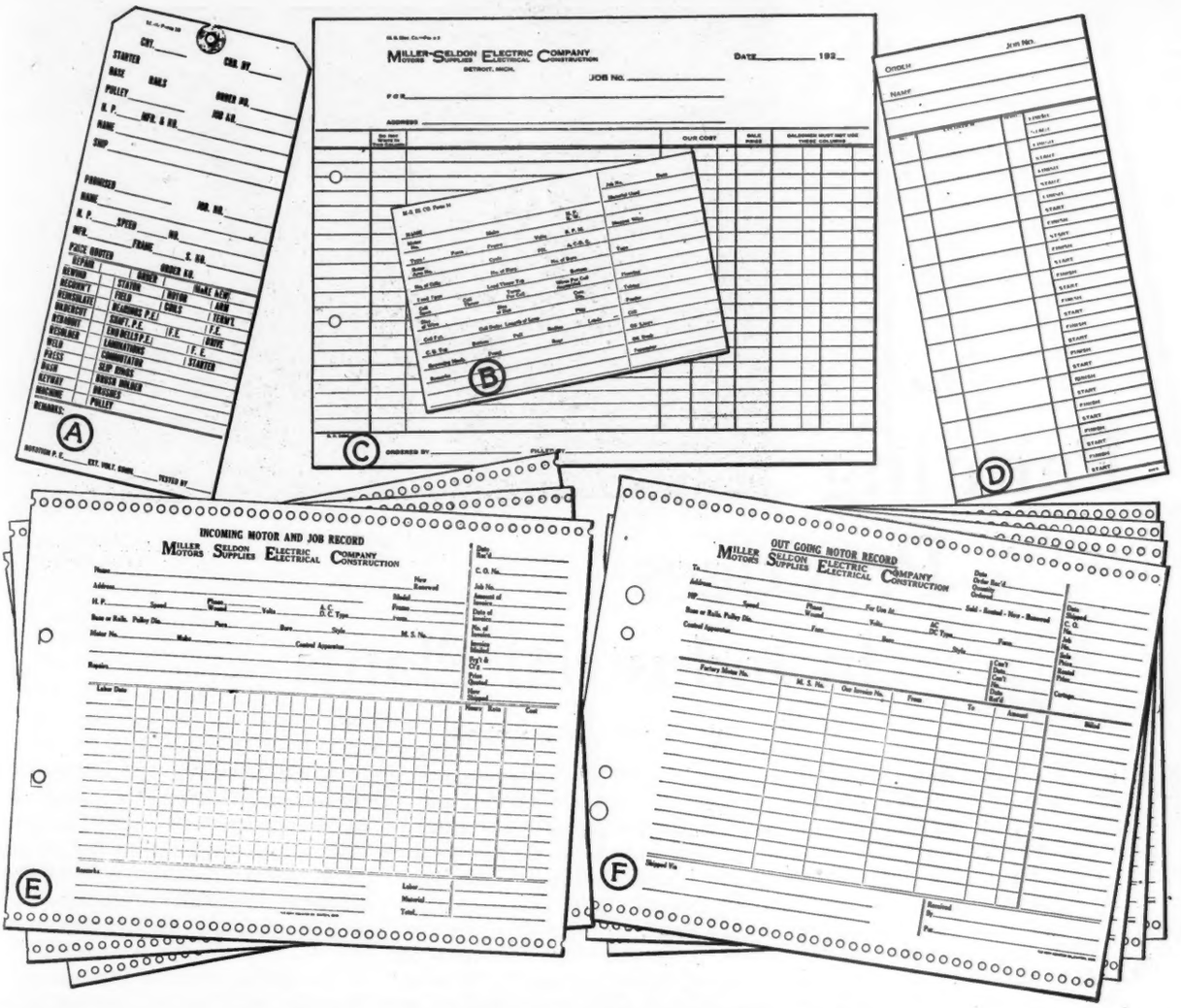


Fig. 9—Here are the forms used in recording data and costs, as well as identifying and billing a job.

As soon as a job is received the tag shown at *A* is filled out and attached to it; the bottom half of the tag is torn off and sent to the office. *B* shows the form on which are recorded the winding data. At the extreme right, space is provided for the coil maker to record the material used in making the coils for this job. At *C* is the form on which all material used is charged from the storeroom to the job. The time for each operation required on a job is put down on the card at *D*. The material and labor costs from *C* and *D* are then consolidated on form *E*, which is made out in triplicate. *F* shows the statement that is presented to the customer. Four copies of this form are made out.

in triplicate, one copy going to the shop, another to the office, and the third to the shipping department.

After the motor has been wound, it is dipped and baked and then given a coat of black spirit varnish, after which it is completely assembled and the exterior iron parts given a coat of gray enamel.

The "Outgoing Motor Record" (shown at *F* in Fig. 9) is then made up in quadruplicate; this is in reality the customer's bill. One copy goes to the shop, another copy goes to the office, the third copy is sent to the customer and the fourth copy goes to the shipping department.

Control and small motor repairs are handled in a similar manner except that they go to a different part of the shop to have work done on them.

There is one little scheme for keeping track of the parts of a motor after being taken apart, which should be mentioned. All parts of a motor, except those that are to be repaired, are stored in one bin which is marked with the job number of the motor that is being taken apart. These bins are located in the place marked "shelves" in the small motor repair section shown in Fig. 2. In this way, the parts of a given motor are kept together and do not get lost or mislaid while the motor is undergoing repair.

The distribution of the personnel required to operate this shop is very interesting. The control of the shop centers under one man, the shop superintendent, who has an assistant superintendent and two clerks to help him with the office work required. Directly in charge of the men working in the shop is a shop foreman and under him are the following:

3 men for testing
4 men for cleaning and stripping
4 girls for making coils
6 men for winding
7 to 10 men for assembling
2 men for dipping and baking
6 men for small motor repairs
1 welder
5 machinists
2 men for control repair
1 man in charge of storeroom
5 men for outside service work

This list is subject to some fluctuation, but the number of men in the shop averages 45.

Repairing motors and other electrical equipment does not differ materially from the manufacture of any product. In both cases it is important that the various operations be performed with the least amount of waste time and effort. We feel that the manner in which we have arranged our equipment accomplishes this end.

Applying aluminum paint in a Cleveland factory. Cost and other data on this particular painting job are given in the box on page 80 of this article.

Painting Practices In Industrial Plants

By FRANK E. GOODING

Associate Editor,
Industrial Engineer

PRACTICALLY every industrial plant has a different policy with respect to painting the factory interior and exterior surfaces. This policy is usually a reflection of the ideas of the management in regard to good housekeeping and the value of good lighting. Generally, poorly lighted plants are also badly in need of a coat of paint, which would go far toward making brighter surroundings and permit the light striking the ceiling to be reflected instead of absorbed.

In plants which are suffering from defective production, due to carelessness and poor light, cleaning and brightening up the interior will often improve the quality of the workmanship. Poorly kept surroundings are commonly reflected in a slovenly attitude toward production. Although it is difficult to measure direct returns from painting and cleaning, the management in practically every case after a shop is brightened up attributes at least part of the improvements in quality and quantity, as well as a better attitude of the workers, to the improved appearance of their surroundings.

The article entitled, "Lighting Value of Paint in Industrial Plants," by M. Luckiesh and E. W. Commery, Lighting Research Laboratory, National Lamp Works of General Electric Company, Nela Park, Cleveland, Ohio, which appeared in the August, 1926, issue of INDUSTRIAL ENGINEER, discusses the relative reflecting value of paint and the loss of light due to the decrease in the reflecting value of the paint, through the accumulation of dirt. In this particular article it was pointed out that the monetary loss from the light paid for but lost by being absorbed and not reflected by the soiled walls would, even in the comparatively clean surroundings of the drafting room under observation, be sufficient to make it economical to repaint about every 14 mo. Conditions are much worse in most industrial surroundings where repainting schedules are seldom on less than an every-third-year basis, and more commonly at longer intervals.

The value of white paint for ceilings is so well recognized by those who believe in frequent painting that any other color is now seldom used. The question of the relative values of flat and glossy white surfaces is also so well covered in the article in the August, 1926, issue, that it will

Mill white brightens up this press-room interior.
The paint on this interior was applied with a Vortex gun. Complicated machinery, such as shown here, increases the cost and difficulty of doing the work if scaffolding has to be built over the machines.

Much can be saved in time and cost if the building is painted before the machinery or equipment is installed.

A simple, plain scaffolding made from painters' ladders and planks is used with this two-man DeVilbiss unit. The bare floor is easily covered with tarpaulins.

not be taken up further here. The present article will deal with the painting practices of various industrial plants.

As previously stated, housekeeping is made easier by well-painted surroundings. Dirt may be allowed to linger in dark corners, but when these corners are painted white even the most careless men hesitate to spoil them, particularly if the management has shown emphatically that it intends to keep these places clean. One of the best examples of this is the now common practice of painting the corners white on stair landings, to eliminate the unsanitary habit of expectorating in the dark corners.

Following out this same plan one Chicago factory paints a white baseboard along the walls of the room. The remaining wall surface is battleship gray up to about 5 ft.; the ceiling and upper walls are white. Still another Chicago factory paints a similar white band around the foot of each column or post and also extends the white surface out on the floor about 10 in. from the column.

Food factories, particularly because of the careful inspections for cleanliness required under local or state regulations, are turning to washable white walls to aid them in maintaining a clean plant. Lacquers are being frequently used here, because of the large amount of cleaning which is necessary. In some cases the walls or parts of them must be washed at least once each day and are often wiped off several times a day.

For example, in a candy factory when chocolate is spattered on a white wall, it is cleaned off at once, whereas, with dark walls, on which such spots will not show, the chocolate would be likely to remain there and the walls be cleaned only at long periods, which would not meet with the approval of the inspector. The lacquer, which is in the same class of covering as the Duco finish on automobiles, will, it is stated, stand this repeated cleaning and washing. Some other types of factories are also coating interior surfaces with lacquer, so that cleaning may be done more frequently without the necessity of repainting.

A printing establishment painted its glue room white all over, even the floor, and all glue spots are now cleaned up before they harden. This had been a particularly difficult place to keep clean because the hardened glue could be removed from the walls only with considerable effort. Many other plants use white paint similarly to keep the rooms clean and free from objectionable marking.

When deciding on a painting plan, one of the first problems is to select a color scheme. As stated, either a mill, flat or lacquer white is now the commonly accepted color for ceilings, although aluminum paint is being used in some plants. Industrial plants differ in their practices in regard to the color used for walls. In some plants, the same color used on the ceiling is extended down almost or entirely to the floor. A more common practice is to use a darker paint for the dado on the wall, which varies in different plants from about 3 ft. to 6 ft., with a height of 5 ft. probably predominating. Battleship gray is a common and pleasing color for wall dadoes, although light and dark brown and other dark colors are sometimes used. It must be remembered that the darker the wall paint, the less its reflecting value, and walls should have some reflecting value.

Two objections are sometimes raised against using a light color on a wall: Sections within reach, which are exposed to trucking and moving of materials, become soiled

Another application of aluminum paint.

Practically the entire interior of The Reynolds Electric Company plant has received one spray coat of aluminum paint. Lights are practically unnecessary on all floors except the first, during fair daylight. This light well and crane bay supplies light to the center of the building. The color scheme is shown in a box on another page.

Applying a protective exterior coating with a DeVilbiss gun.

quickly and the glare from the light surface is objectionable where workers are forced to face a white wall when it is exposed to the sun or other bright lights. The latter is probably the more serious objection because the white walls *can* be kept clean, at least they are in many plants. Of course, material cannot be piled against white walls, nor trucks bumped up against them, two points which, from a housekeeping standpoint, favor the white wall.

Columns and posts, however, are frequently painted a darker color for 4 or 5 ft. up from the floor, because of the greater difficulty in keeping them clean in that they are more in the way and are also more likely to be touched with dirty hands. There is less excuse for touching a wall than a column or post.

Whether to use mechanical painting or not depends largely upon the amount of surface, its character, and the difficulty of covering up or working around the equipment in the plant. Whenever it is possible to get into an empty building, or when the equipment is not in operation, and so can be covered up without interference, mechanical painting, usually, has a considerable economic advantage over brush painting. This is particularly true of rough surfaces, such as brick, unfinished or rough lumber and so on, which are hard to brush. Aluminum paint and lacquer are more easily applied by mechanical painting equipment than by brushing.

When the areas to paint are small and so increase the amount of shifting of the tarpaulins and other protective equipment, there may come a point where the economy of the spray method in coverage is overbalanced by the increase in the cost of protection and shifting the equipment. It requires experience to be able to tell how a surface can be most economically painted. Steel sash, for example, is seldom painted with a gun. Some industrial men do not believe that it pays to paint the narrower columns between windows with a gun, although others do.

Ordinarily, mechanical painting is estimated at about half the cost of brush painting, sometimes more and in other cases less. Although the former often requires more paint, particularly with a less experienced operator, the labor cost is lower. Constant shifting of apparatus or protective coverings, because of broken-up wall areas, increases this labor cost. Trimming and painting of pipes and similar work is usually done most economically by hand painting; this is almost essential where the paint used is of a different color than the background.

None of the industrial concerns interviewed in connection with the preparation of this article found any difficulty in obtaining operators for their mechanical painting equipment. Some of the companies were able to take men engaged on paint booth work and assign them to a portable paint spraying outfit for building work. Other concerns pick either painters or handy men from the maintenance gang and break them in on the use of the gun. Manufacturers of painting equipment, however, complain that these men do not know how to take care of the gun, hose, and paint chambers, and so do not clean them out when they are put away after the job is finished. The man in charge of maintenance should see that this is done. The manufacturer will supply directions.

Frequently, painting is done at night because that causes the least interruption to production. For example, at a Chicago factory, engaged in light manufacturing, with most of the work performed on sewing machines, three floors, about 300 ft. long and 100 ft. wide, were painted at night by the painter with the help of the janitors for shifting the tarpaulins. In this case, canvas curtains extending to the floor were suspended by hooks from the sprinkler and other overhead pipes. These were hung so that they partitioned off an area approximately equal to a building bay; a single column, however, was in the center of the enclosed area instead of a column at each corner. The janitors also covered up any machines or stock with tarpaulins and moved the entire enclosure as necessary. While the operator was painting, the janitors went on with their other cleaning work.

Light was supplied by two portable lamp stands, the reflectors being turned upward towards the ceiling. Sprinkler heads were covered by slipping a light paper bag over them.

Cost Data on Aluminum Painting

(Cleveland factory; Paasche air brushes used.)

Area coated
First Coat: 265,000 sq.ft.
Second Coat: 185,000 sq.ft.
Total: 450,000 sq.ft.

Men employed
4 spray operators: 2 or 3 helpers part of the time; at other times none. Average 2 helpers.

Time
823 spray hours

Rate of coverage per gun
547 sq.ft. per hr.

Material
2,500 lb. aluminum powder @ 53c. per lb.
1,800 gal. bronzing liquid @ $1.20 per gal.
Total—$3,583.
This is equivalent to
0.7962c. per sq.ft. or
79.6c. per 100 sq.ft.

Exterior as well as interior walls can be repainted by the spray gun.

For such exterior surfaces, it is best to use special brick or stone paint. This is a Paasche air brush job. In some places cement is mixed in with the paint as a vehicle and applied with a gun having a slightly larger opening than is used for ordinary paint.

Brightening up the interior of an industrial plant with white paint.

The difference in the light-reflecting qualities of a surface before and after painting is well shown here. Matthews mechanical painting equipment was used on this job.

It was estimated that at least 25 per cent was saved on the cost of this job by doing the work in this way instead of letting it out on contract. A painter from the maintenance gang operates the gun. He is kept busy at other times on the many miscellaneous painting jobs which have to be done in a plant of that size.

In most of the other plants visited painting is handled in practically the same way. Much can be saved by planning ways to support the curtain surrounding the area to be painted and by using scaffolds which are easily erected and shifted. Fastening the curtain to a cross-pole and then using other vertical poles to hold it in position is, perhaps, one of the quickest methods of erecting a curtain where it cannot be hung from overhead. This same plan can be used to protect a window either in the wall or in a saw-tooth roof. Horses for scaffolds can usually be built the proper height for the ceiling, or made adjustable.

The surface to be covered must be in practically the same condition for either brush or mechanical painting. Cold-water paint must be washed off. Grease spots must be removed. New work requires more coats to cover it. It is seldom advisable to try to apply an extra thick coat and make one coat do. Resinous knots require shellacking. All of the many precautions necessary with painting must be followed, irrespective of the method of application.

Aluminum paint instead of white paint is being used by a number of industrial plants for ceilings and walls. These are mostly new jobs and will be under close observation by industrial men to determine their lasting qualities, the effect of dirt, how well they can be cleaned, and other operating features.

The Reynolds Electric Company, Chicago, Ill., manufacturers of sign flashers, recently painted practically all the factory ceilings and walls with aluminum paint. A view of the plant interior is shown in one of the accompanying illustrations. This is an interesting paint job and will be described in considerable detail. The ceiling had been painted with mill white about 6 yr. previously, and washed about 3 yr. ago. The brick walls had been coated with a cold-water white paint which had to be washed off.

Before repainting the entire plant, two adjoining bays in the darkest part of the building were painted—one with a mill white paint and the other with aluminum paint. After a short period of observation, it was finally decided to use aluminum paint. A painting scheme, as shown in the accompanying box, was then drawn up. The operator started on the top floor and worked downward. When he was working in a section the machines were covered with tarpaulins, and sawdust was sprinkled over the intervening floor spaces. Aluminum paint is rather difficult to hand-brush and so all surfaces coated with aluminum were sprayed. A handy man was hired for this work.

The brick walls were washed to remove the cold-water paint and also had to be sized before coating with aluminum paint. The varnish, which is used as a vehicle for the aluminum paint, was sprayed onto the brickwork to form the sizing coat. In this case, the entire walls were covered

Color Scheme at Reynolds Electric Company

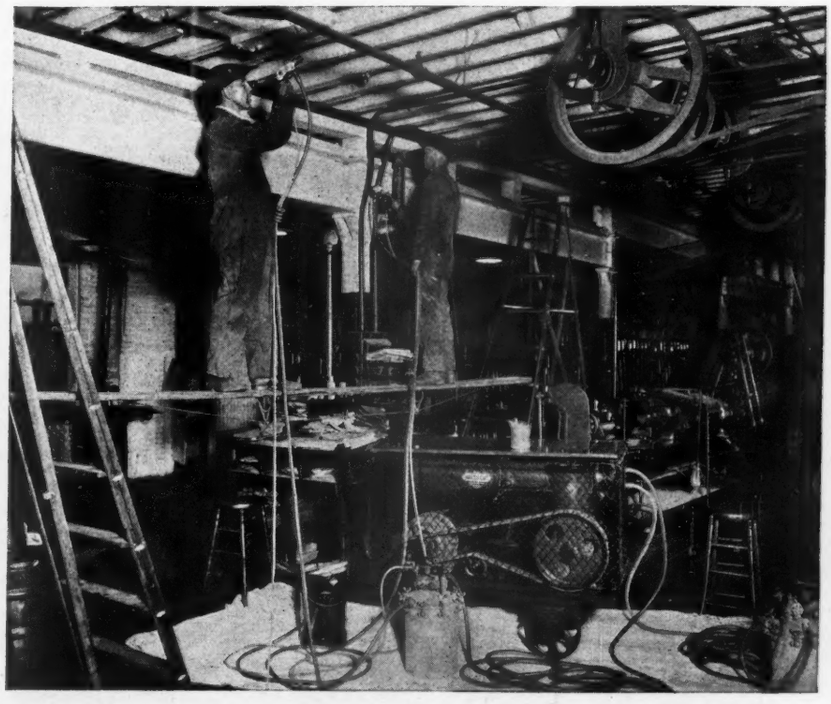
Ceiling—Aluminum paint
Walls—Aluminum paint
Columns—56-in. battleship gray dado
Inside partition—56-in. battleship gray dado
Floor lines—Egg-shell mill white
Machines—Gray oil-proof machinery paint

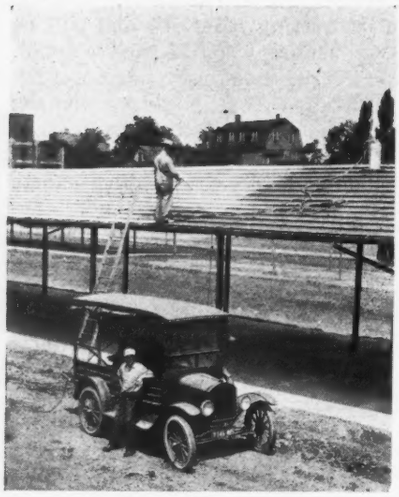
Piping Color Scheme

Hot water—Olive green
Steam returns, and radiators—Medium brown
Compressed air—Light blue
Cold water—Battleship gray
Gas—Black
Conduit—Painted same color as surface on which it lies
Sprinkler system—Bright red
Drain pipes—Light lead gray
Fire extinguisher markers—Bright red band around column on which extinguisher is mounted.

Two men working on one scaffold can quickly cover a large area.

If the floor is protected by tarpaulins or sawdust, there will be no paint spots to clean up. These operators are using a Matthews mechanical painting outfit.





On this job the painter averaged 12,000 sq.ft. per 8-hr. day.

A special Truscon protective paint was applied to this roof with a Paasche air brush.

down to the floor with aluminum paint. It was desired to keep the outside walls clean and to prevent anything from being piled up against them or in the corners. The amount of aluminum paint used each day had to be mixed daily. It is mixed in the proportion of 1 gal. of varnish, 1 gal. oleum spirits, and 4 lb. of aluminum powder.

A battleship gray dado 56 in. high was used on all partitions except on the brick walls along the outside of the rooms. Columns and posts were also given a battleship gray dado.

The floor lines for trucking aisles were painted with egg-shell mill white. In addition, all factory machines were painted with a gray oil-proof machine paint. These, of course, were hand-brushed jobs.

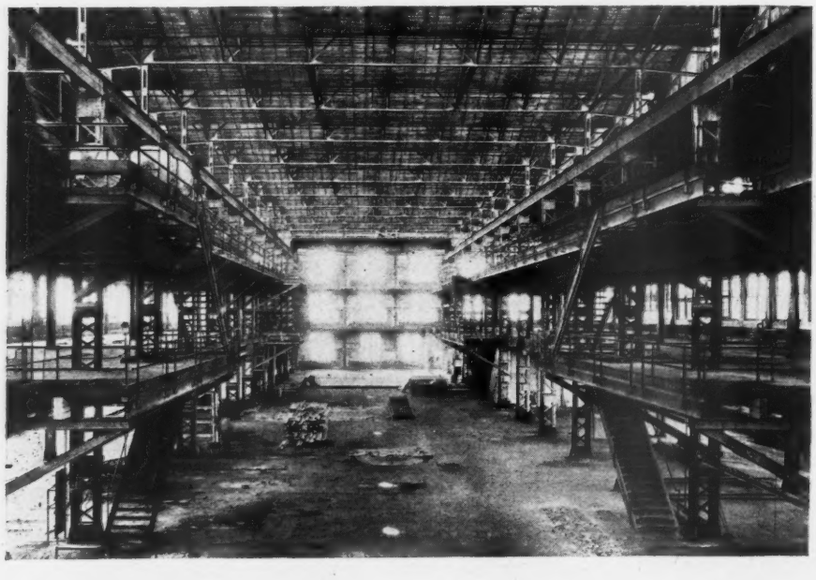
The color scheme for the piping layout is given in the accompanying box. One interesting point about the piping color scheme is that conduit is painted the same color as the background on which it lies. This item alone saved considerable in the cost of the painting because most of the conduit work lies directly on the ceiling, walls, or columns, and if it were painted a different color would necessarily be a brush job, whereas it was covered up by the gun as the ceiling was painted. The other pipe lines were all a short distance from the wall and required brush painting.

Reference to the illustration of the Reynolds factory shows a most interesting construction. The building does not have any elevators. A light well in the center of the building extends from the basement floor to the top floor and is served by an overhead crane. Platforms at the end of this light well are offset on the different floors so that the crane can deposit or pick up a load on any floor. The entire plant is practically day-lighted from this light well and the windows. Since it has been brightened up with aluminum paint comparatively little artificial light is required during the day.

EDITOR'S NOTE: Acknowledgment is made to the following manufacturers of painting equipment for information and illustrations: Binks Spray Equipment Co., Chicago, Ill.; The DeVilbiss Co., Toledo, Ohio; W. N. Matthews Corp., St. Louis, Mo.; Paasche Air Brush Co., Chicago, Ill.; The Peerless Pneumatic Systems, Chicago, Ill.; and The Vortex Mfg. Co., Cleveland, Ohio.

Here is another interior view of the plant shown in the headpiece on page 78.

This plant was finished inside with aluminum paint, as described in the text. Note the open construction and amount of steel work to be painted.



Storage Battery Trucks

(*Continued from page 65*)

So that the men will know about it practically as soon as any parts begin to show signs of wear, a monthly inspection is made of each truck at which time it is also oiled and greased. Each day one truck or tractor is taken out of service and all wearing parts given a complete inspection before they are again lubricated. It takes about a month to go over all the fleet. The gear or worm-drive cases are drained and the inspection plate removed. If the gear teeth show wear, the cause is found and removed. The case is then filled with lubricant and the cover replaced. The differential is oiled, but not opened up and inspected, each month. The driving coupling is also inspected, because if it loosens up it soon destroys the key. The bearing retainers are also examined by removing the hub plates and tightened, if necessary.

Most of the bearings have Alemite fittings and are grease lubricated with a pressure gun. In addition, the steering handle and mechanism are tightened or adjusted, the automatic disconnect tested out and inspected, loose bolts and nuts tightened, tires inspected, and both the operating and emergency brakes inspected, tested and carefully adjusted.

Once a year, however, each truck is taken apart, the grease chambers and feed lines cleaned out, all parts carefully checked for wear, and renewed or tightened up where necessary. After this overhauling, the truck is re-assembled, oiled and greased, and is operating again practically as good as a new truck. Except for the daily and monthly inspections and the annual overhauling, the trucks are seldom out of service or in the shop.

The management most heartily recommends its practice of regular inspection and lubrication of these trucks and tractors. Just how much it saves is, of course, not known with certainty, and can be only roughly estimated. However, it is definitely known that practically continuous service is obtained from the equipment, and that cost of inspection, together with the necessary adjustments and the few repairs, are also low. It always costs less to make a minor repair than it does to make a big one.

IN THIS ISSUE

You May Find the Solution of Your Problems

worked out in the recorded experiences of other operating men

I HAPPEN to know that the Editors of INDUSTRIAL ENGINEER have spent a lot of time on this issue in order to present to plant operators the most effective and least expensive methods to use in connection with maintenance and replacement of plant equipment. After it has been carefully read I recommend that it be put aside where it will be available for handy reference throughout the year. You are certain to run into some or all of the problems discussed, and you will save much time and money by reading the experiences of others and finding out how they solved these problems.

TO PUT it another way, it pays to avail yourself of the experience of others, and INDUSTRIAL ENGINEER endeavors to present the solution of operating problems in such a way and in such variety that its readers can save money.

IN EVERY plant the number of motors is increasing year after year, and with the increase in number come new installations and new processes that must be studied from the standpoint of continuous motor service with as few rewindings and repairs as possible. In this connection I had an experience only the other day that shows the value of drawing on the experience of others, instead of floundering around with experiments that are costly and may or may not lead somewhere.

I WAS called into a large smelting plant to recommend a varnish insulation for motors used in connection with a new process that was truly a motor-killer. It involved zinc chloride fumes and a deposit that required rubber gloves to prevent nasty sores on the hands when inspecting the motors. These fumes and the deposit just raised hob with the ideas of an experienced motor man regarding insulating varnish, and he needed help and asked for it.

WHENEVER you have any puzzling questions on the operation or repair of the equipment in your charge and want information, let us know. We will be glad to offer suggestions, tell you how and where to obtain the information you need, and secure from other plant operators the details of the methods they are using. This is one way to get results quickly, at the least expense in time and trouble to you.

BETWEEN us we made a thorough study of the situation and gathered all the necessary data. Then we wrote a letter to a well-known varnish manufacturer and back came a sample gallon of varnish with full instructions on how to use it. To him the problem was not new and he knew exactly how to go about the necessary correction. These instructions are now being followed and in a few months, after more experience with the situation, I feel certain that we shall have some interesting details about this job for publication.

THE point is that there is a way to get out of almost every difficulty, and the quickest way is to search out the source of information on the subject. Too often we have a tendency to continue doing things as best we can, hoping that a time will come for a complete investigation. That time seldom comes to a busy operator until a serious operating condition faces him, and then to drop everything else is the most expensive method to follow. Troubles are cured quickest and at lowest cost when they are small, and here is where you will find articles such as appear in this and every issue of the greatest value to you.

WHEN you are in trouble, you will always find the Editors of this publication and my humble self lined up on your side. We try to keep you out of trouble through the program of articles prepared for publication, but if you do get into trouble, we are always ready to get under and help you pull out without ever saying, "I told you so" or asking you why you have not read your copy of INDUSTRIAL ENGINEER more thoroughly. In fact, we welcome the opportunity to get acquainted with you, learn your problems, and find out the kind of information that you may need from time to time.

Practical Pete

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Editor*

The Purpose of This Issue

ONE of the real dangers that confront all of us is that we will allow satisfaction with present accomplishments or conditions to blind us to the ever-present opportunities for improvement. Even the ultimate in perfection today will be surpassed tomorrow.

For this reason it is necessary to check up our ideas and practices frequently, both by comparing them with the ideas and practices of other men, and by examining them critically from the background of our own experience. The purpose of this issue is to stimulate the thinking of industrial operating executives on two of their most important problems—careful and efficient maintenance of equipment so long as this is profitable, and prompt replacement when conditions make this advisable.

The methods and viewpoints outlined in this issue represent the thinking and planning of many men with years of practical experience behind them, and are worthy of careful study. Although all of the minor details of any method or system of procedure may not be applicable to every plant, general principles whose worth has been demonstrated in actual practice can profitably be applied under almost any conditions.

It is hoped and believed that this issue will throw additional light on the important problems discussed, and will point the way to their successful solution.

Give Insulating Varnish a Chance

IT IS rather difficult to find a definite agreement among repairmen on the application of insulating varnish to motor windings. Years of experience have taught certain lessons, and current practice in any one shop seems to be based on the experience of the oldest member therein. The use of air-drying varnishes applied by dipping, pouring or brushing will be more or less successful where insulated coils are purchased and a finish coat is used to provide oil-proofness. In some shops where air-drying varnish is mostly used, motors that are known to be subjected to extreme conditions of service will receive treatment with a baking varnish and be baked for a varying period, depending upon the varnish used.

In industrial repair shops, and also in commercial repair shops where a wide variety of rewinding is handled, it has been proved beyond question that the application by dipping of a varnish with good penetrating, covering and cementing qualities, and then baking in a good oven for a definite time to remove the varnish solvent, is the safest and cheapest method to use when vacuum impregnation cannot be employed. The dipping method insures that all crevices in the winding slots will be filled.

When air-drying varnish is employed, it is usually purchased in gallon quantities. On this basis 55 1-gal. cans of a good grade of varnish will cost around $120. If baking varnish is purchased in 55-gal. drums, the cost should be about $80, so that there is a material saving on the basis of the quantity purchased at one time that can be applied towards the necessary dipping tank and baking oven required for a baking job.

This is one good reason for doing away with the brushing and pouring method of applying air-drying varnish, except perhaps on certain emergency jobs. The other reason is that you can not afford to do anything but the best job possible when rewinding a motor.

Proper Attention to Bearings May Prevent a Fire in Your Plant

EVERY operating engineer is, unfortunately, only too familiar with the trouble and expense that may be caused by a hot bearing, particularly if it is located on an important piece of equipment. However, it may not be so well known that hot bearings occupy a very unenviable position from the standpoint of fire hazard, as Edward N. Harriman points out in the October *Quarterly of the National Fire Protection Association.* In this article the statement is made that hot bearings are probably responsible for the major part of the losses, averaging around $8,000,000 annually, classified by the Actuarial Bureau of the National Board of Fire Underwriters as "Friction sparks caused by machinery."

The N.F.P.A. Department of Fire Record has since March, 1925, been keeping a record of fires caused by hot bearings. Up to September of last year, 63 such fires have been reported, including a few important fires prior to 1925. The greater number occurred, as would be expected, in occupancies where combustible dust or flyings were present. Thus, of the 63 fires reported, 28 occurred in cotton mills and other textile occupancies, 9 in paper mills, and 8 in woodworking establishments.

Where fires did not start and spread in combustible dust or flyings, oil-soaked wood or dirt in the vicinity of the bearings was frequently to blame. Careful attention to bearings, and mounting them on incombustible bases, should eliminate a large part of this hazard.

It is obvious that practically all of these fires were the result of neglect. Usually the original reports do not give the exact reason for the heating of the bearings, but occasionally cite specific failure to lubricate them. Similarly, in only a few instances do the reports indicate the exact type of bearing responsible for the fire. In the absence of a specific description, it is probably safe to assume that in most cases they were the plain type, rather than ball or roller bearings.

To say that neglect is the cause of most of the trouble

with sleeve bearings does not solve the problem. So long as oiling and care of bearings are turned over to an unskilled and sometimes more or less irresponsible laborer, as is frequently done, trouble will be encountered.

Most of the trouble with plain bearings can be prevented by putting them under the care of a conscientious workman who has some real knowledge of bearing construction, providing him with suitable lubricants, and exercising sufficient supervision to make sure that the schedules laid down are strictly adhered to.

How Much of Your Equipment Is Drawing a Pension?

HUMANITARIAN considerations may make it highly commendable to give an old and faithful employee an easy job and retain him on the payroll long after his services have ceased to be really valuable. Such considerations do not, however, apply in the slightest degree to plant equipment. This is, or should be, purchased and operated strictly on the basis of its value as an investment, and when for any reason it ceases to pay a satisfactory return it should be discarded at the first opportunity.

One may feel a justifiable pride in pointing to some old machine or device that has been in service for many years and is still in good condition. However, unless it can be shown that that machine is reasonably comparable in efficiency with modern designs, its place is on the junkpile or in a museum—anywhere, in fact, except out in the shop.

In an article on page 51 of this issue, a large number of plant operators and manufacturers discuss the question of replacing obsolete equipment from the standpoint of the yardstick that can be used in determining the real worth of old apparatus, and the conditions under which replacement can be justified.

Study of your equipment in the light of the facts and viewpoints expressed in this article may show how you can most effectively solve the problem of reducing maintenance costs and increasing production.

The Best Safeguard for All Hazards

EVEN with the best safety devices on electrical equipment and circuits, many points cannot be guarded so that they are absolutely fool-proof. Men working around such equipment must exercise care and intelligence, even to a greater extent, perhaps, than in connection with most other industrial equipment or devices. If proper precautions are taken, and practically every experienced man should know them, electrical circuits, even with the highest voltages commonly used around industrial plants, should not offer an especially serious hazard. If the ordinary precautions are ignored, however, the result may be a serious or fatal accident.

New, inexperienced men are not the only ones guilty of neglect or carelessness. For example, an electrician in a mid-Western city was killed when he put his finger into a 2,300-volt pothead to see if the circuit was alive. It was. This man had worked five years for the company and was thoroughly familiar with all necessary precautions that should have been taken.

It is almost impossible to safeguard 100 per cent against accidents such as this. For these and many other hazards the best means of prevention is a careful man. Those supervising others engaged in electrical work should keep continual watch over their subordinates to see that unsafe practices are not followed and that precautions for personal safety are not disregarded. Also, the men with whom "familiarity has bred contempt" require as much watching as the men who are so inexperienced as to be afraid.

Look Outside Your Industry for Ideas

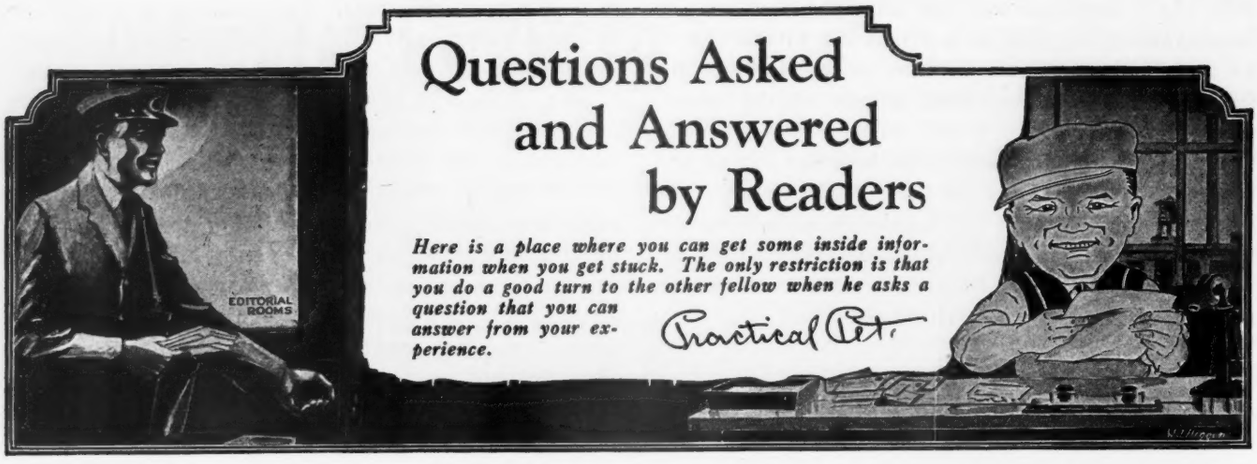
EVERY operating executive should feel proud, and justly so, when he has developed original ideas and applied them to his own industrial problem. The opportunities for entirely new ideas, however, are fewer than are the occasions for adapting those common in other industries to meet the requirements of the problems he is facing.

Strictly original ideas usually require research, for which operating men seldom have the time or facilities. Every industry, however, can adapt many of the methods and practices in vogue in other industries. These may be obtained from plant visits or through the descriptive articles appearing in publications such as INDUSTRIAL ENGINEER.

Lack of the broad-visioned ability to analyze and discover the basic principles in operating plans is one of the common shortcomings of operating and also many other executives. Men with this ability, if they have any executive talent, are practically sure of advancement to positions where they can devote more time to mental effort, which practically always obtains greater reward for both the company and the men than does mere hand work.

As an example of this, the inspection record which is the basis of a very successful method of handling maintenance work was adapted from the air brake inspection system used on railroads. To many, freight cars and woodworking machinery would seem to have no relationship, but the inspection plan for one, with the necessary modifications, is working very well with the other.

Incidentally, the mechanical superintendent who worked up this idea has so proved his ability with this and many other suggestions that today he is the manager of another nationally known company. Men of balanced ability, particularly those who have a broad enough viewpoint to work out and apply ideas, have their talents recognized and rewarded, either inside or outside of their organization.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer This

Characteristics of Fynn-Weichsel Motor.—I shall appreciate it if some reader will explain in non-technical terms the characteristics, construction, and principles on which the Fynn-Weichsel motor operates. Is it necessary to use special control equipment with this motor?
Lansdale, Pa. H. T.

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What Is Best Kind of Insulation For Semi-Closed Slot Motors?—I shall appreciate it very much if readers will tell me whether it is better practice to use varnished cambric between each coil in a semi-closed slot motor, thereby insulating each coil from its neighbor, or to tape each coil separately and then use insulation only between phases.
Rome, Ga. M. S. C.

* * * *

Substitute for Shearing Pins.—We have a conveyor line which is driven by a 3-hp. motor through a worm reduction gear. A coupling with a shearing pin is placed between the conveyor and reduction gear for protection when the conveyor becomes clogged, which it frequently does. Some time is required to replace the shearing pin and I wish to eliminate it if I can. Could a clutch be used that would slip and thus absorb the shock when an excessive load comes on, as is the case when the conveyor becomes blocked.
Youngstown, Ohio. J. L. B.

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Advantages of Three-Phase, Four-Wire System.—As there seems to be an increasing use of three-phase, four-wire systems, I shall appreciate it if some reader will answer the following questions: What are the principal advantages of a three-phase, four-wire system over a three-phase, three-wire system? Are there any special conditions under which these four-wire systems should or should not be used? Can three-phase, three-wire, watt-hour meters be used to measure the current consumption in three-phase, four-wire systems?
Pittsburgh, Pa. R. L. P.

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Changing Speed of Electric Drill.—I have an electric drill that I wish to use for other purposes which will require a lower speed. The nameplate is missing, but the present no-load speed is about 1,800 r.p.m. and the full-load speed 1,200 r.p.m. The drill is driven by a universal motor and is capable of boring a ¼-in. hole in steel when operating from a 110-volt, a.c. circuit. Will some reader please tell me how I can reduce the motor speed to one-half or three-quarters of its present value? What is the principle involved in increasing or decreasing the speed of a universal motor?
Moline, Ill. J. M. M.

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Operating Generators in Parallel—We have a 400-kw., three-wire, 110/220-volt, compound-wound General Electric generator which I wish to operate in parallel with a 100-kw., two-wire, 220-volt Crocker-Wheeler generator. Can these two machines be satisfactorily operated in parallel while the 400-kw., three-wire machine is supplying a three-wire, 110/220-volt load? I wish to obtain both 110 and 220 volts from the 400-kw. machine and at the same time increase our 220-volt generating capacity by paralleling the two-wire, 220-volt, 100-kw. machine with it. If these machines can not be operated as described, please give me the reason. If they can be so operated what scheme of connections must be used, and what precautions observed in paralleling them? Any information that readers can give me will be greatly appreciated. J.F.
Dansville, N. Y.

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Answers Received To Questions Asked

Using Large Diameter Pulley on Motor.—Is it practicable to use a 20-in. pulley on a 25-hp., 750-r.p.m. motor? This would result in a peripheral speed of the pulley of 3,926 ft. per min. Would this be good practice? What objections would there be to using this size of pulley on the above motor in view of the fact that the motor manufacturer does not recommend a pulley of this diameter? Can some reader tell me what types of pulleys I could use or could not use in this case?
Toledo, Ohio. F. H.

I believe that F. H. will find the use of a 20-in. diameter pulley on a 25-hp., 750-r.p.m. motor to be sound engineering practice. We have repeatedly made similar installations which have worked perfectly, up to a 36-in. pulley on a 150-hp., 450-r.p.m. motor. In fact, for a short-center drive, a slow-speed motor with a large driving pulley will work much better and sometimes save using an idler.

I believe that the main objection of the manufacturers, and the reason they do not recommend large pulleys, is based on cost considerations. Motor prices run roughly by frame sizes; the same frame size of motor will develop approximately twice the power at twice the speed, so that even down to the cost of the pulley, it is economy to use as high a motor speed and as small a pulley as the speed and pulley diameter of the driven shaft will allow.

The belt thickness must always be taken into account, because if the diameter of the pulley is too small the continual bending of a thick belt over it will shorten its life. Another advantage of high-speed induction motors is that they have slightly better efficiency and power factor than the slower-speed motors. However, where I have a slow-speed motor available I believe that it is better to use the proper size of pulley rather than buy a new motor or trade with a used machinery dealer for a higher-speed motor, the history of which I know nothing.

Any sort of pulley can be used as long as it is well balanced. However, I have found that wooden pulleys are affected by atmospheric changes and are hard to keep tight on heavy service. Most pressed-steel pulleys are a little light for the belt pulls usually encountered on motor drives and unless especially constructed and balanced for high speed the circumference is just enough off the true circle to receive an alternation of stress and a kneading action that eventually loosens up the joints. It must be remembered in both these cases that these types of pulleys are not designed or recommended for this kind of service by the manufacturer.

The standard so-called paper motor pulley operates very well with endless belts or Clipper and similar lacing, but will eventually lose its crown if the belt is allowed to slip much. Paper pulleys are also cut out quickly by certain types of belt hooks, and the use of these in motor belts on paper pulleys should be permitted only as an emergency measure.

This leaves only the cast-iron pulley, and for a large diameter motor pulley the writer would prefer a good, solid cast-iron pulley, turned and balanced for the speed at which it is to run. In cases where these pulleys must be made up locally in emergency I have found that using a pattern with a solid web and finishing the pulley all over will give a pulley that will be sufficiently accurately balanced, without special treatment. H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

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In figuring a belt drive such as F. H. has in mind, it is important that the maximum speed of the belt must never exceed 5,000 f.p.m. Above this speed the centrifugal force reduces the adhesion and consequently the belt pull. [EDITOR'S NOTE: Recent experiments indicate that higher speeds may be used.] Therefore, the pulley diameter

on a 1,725-r.p.m. motor should never exceed 11 in., 16 in. on a 1,140-r.p.m. motor, and 25 in. on a 750-r.p.m. motor. The frame diameter of a 25-hp., 750-r.p.m. motor rarely exceeds 35 in. Motors of this rating are usually equipped with pulleys about 12 in. in diameter with a 12-in. face which is intended for an 11-in. belt. These are the proportions which give a conventional and well-proportioned appearance.

Motor manufacturers do not recommend the use of oversize pulleys because of the possibility of extra bearing trouble, belt slippage, increased likelihood of overloading, and unsymmetrical appearance. However, there are many successful installations of motors of comparatively small horsepower with oversized pulleys for short belt drives where the high speed of the driven pulley is essential and it is not desired to use countershafts.

It is both possible and practicable to use a pulley 20 in. in diameter on a 25-hp., 750-r.p.m. motor providing the pulley is accurately balanced and the motor bearings are rugged enough to carry the extra weight of the oversize pulley and belt.

A well-made cast- or pressed-metal pulley or a wooden or fiber pulley should give complete satisfaction, providing there are no unusual local conditions to contend with, such as excessive dust, moisture or acid fumes at the place of installation.

East Kingston, N. H. H. S. RAMSAY.

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The following experience in the use of a large diameter pulley on a motor will probably be of assistance to F. H. Some time ago when testing ball bearings for endurance we ran them continuously at high speed under heavy load until they broke down. Sometimes this necessitated operating for weeks at a time without stopping.

This job required a 50-hp. motor, but there were available only two 25-hp., 750-r.p.m., squirrel-cage motors, which we ran in multiple. To obtain the desired speed on the bearings undergoing test it was necessary to equip these motors with 24-in. pulleys for 8-in. belts. This gave a peripheral speed of 4,712.4 f.p.m., which is higher than F. H. intends to use. The pulleys which we used had cast-iron hubs and spokes with wooden rims. This test extended over a period of 8 mo. and no trouble was experienced with the motors or pulleys.

Using a large diameter pulley on a motor is not good practice, but F. H. should not experience any difficulty, if our tests are to be taken as a criterion.

Chief Electrician, Savage Arms Corp., Utica, N. Y. W. J. LEES.

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Operation of Electric Refrigerator—Would there be any objection to using brass valves, pipes and fittings, instead of copper, between the compressor and cooling coils of a small electric refrigerator, similar to a household unit, that uses sulphur dioxide as the refrigerating medium? What material is best suited for use as packing and gaskets? What kind of lubricating oil is best adapted for the compressor? What pressures should be carried on the intake and on the discharge when the compressor is running, and when it is not running? What is the best method of charging a unit of this size? I shall be very grateful for any information that readers can give me on these questions.

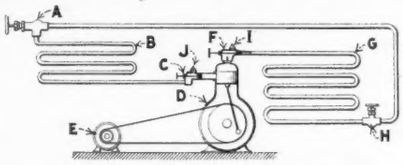
Oak, Neb. H. L. M.

In reply to H.L.M., brass pipes, valves and fittings may be and are used; in fact, iron pipe and fittings could be used. The things to guard against are moisture and foreign particles on the inside, and a multiplicity of joints. Copper tubing is usually used, most manufacturers furnishing a specially dried, annealed and tested tubing. Belled, automobile-type fittings are used for unions and at the pipe ends.

Thin asbestos composition or paper gaskets are used. I have employed blotting paper successfully in an emergency. Packings, when used, are usually of the metallic coil type.

Moisture-free mineral oil, exactly similar to the familiar "American Oil" used internally, is the best, but boil it before using.

The intake and discharge pressures



General arrangement of a refrigerating machine that utilies sulphur dioxide gas.

The expansion valve is shown at *A*. *B* is the expansion coil. The suction shut-off valve is located at *C*, *D* is the compressor which is operated by motor *E*, *F* being the discharge shut-off valve. The condenser coil and shut-off valve are located at *G* and *H* respectively. *I* is the plug in valve *F*, and *J* is the plug in valve *C*.

vary a great deal with the type of condenser, expansion valve or float valve, and expansion coil; in other words, with the type of expansion system used. With Kelvinator outfits the pressures vary, with the size, from 1 in. vacuum to 3 lb. pressure on the low side when running, and from 50 lb. up, on the high side. The high side or discharge pressure varies with the room temperature around the condenser coil. When the machine is not running the pressures tend to equalize, depending on the condition of the compressor valves and expansion valve.

To charge a unit of this type, it is necessary to go through several operations, and the exact way the "charge" is placed in the unit will vary a great deal with the layout of the various parts of the system. With the Kelvinator outfit a vacuum can be drawn on the system after removing plug *I*, part of valve *F*, as a means of expelling the air in the system, and after the system is shut off at *F*. A gage is installed in the plug opening *J* in the suction shut-off valve *C*. When as complete a vacuum as possible is obtained, the plug hole at *I* is filled with compressor oil. If the oil does not sink in or bubble, the system is considered to be tight.

The next step is to connect a drum of sulphur dioxide, equipped with proper fittings and valve. A blow torch will also be required. The drum is screwed (loosely at first) into the highest point in the unit. The plug at *I* and the drum valve are opened slightly for a moment in order to allow the gas to displace the air in the passage between the drum and the valve *F*. Tighten the connection between the drum and the valve. The valve *F* is adjusted so as to open the passage between the drum and the condenser coil *G*, and then the drum valve is opened, the liquid sulphur dioxide now being able to flow into the condenser coil. Heat the bottom of the drum with the torch; close the valve *F* so as to shut off the plug *I* from the drum; remove the drum, and the charging is complete. With other machines the filling operation may be different, although the general principle is essentially the same.

The essential point to remember when working with sulphur dioxide is that when it is mixed with water (or moisture from the air) sulphurous acid is formed, which will at once corrode the pistons and cylinder walls and may cause the pistons to seize; so every precaution must be taken to keep air or moisture out of the system.

Manchester, N. Y. GARSON A. REESE.

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In reply to H.L.M.'s questions, I know of no reason why brass cannot be used instead of copper for the connections between the compressor and cooling unit. Brass is successfully used for this purpose in several of the machines now on the market. Dry sulphur dioxide has very little chemical action on metals.

For gaskets at the header on the cooling coil use lead; at various other places on the compressor, paper gaskets, well shellacked, may be used. For packing valves use single-strand Mogul. Use new packing whenever the stems are removed for any reason.

Ordinary oils should not be used in a machine employing sulphur dioxide as the refrigerant. The oil to be used must be one which has undergone a special refining process. This oil is readily obtainable from any of the manufacturers of electric refrigerators using sulphur dioxide as a refrigerant.

On the intake or high-pressure side, the working pressures are from 50 to 60 lb. per sq.in. The pressure on the discharge or low-pressure side is atmospheric or zero gage pressure.

If the machine is to have its initial charge, it is best to first draw a vacuum. First, the compressor should be baked in an oven at a temperature of about 200 deg. F. for about 1 hr.

Next make a three-way connection at the head of the compressor. One line should go to the charging valve on the compressor, one to the SO_2 (sulphur dioxide) container, and the third to the vacuum pump.

Draw a vacuum of about 28.5 in. for 20 min. After the vacuum has been drawn, close the valve connecting with the vacuum pump, and open the valve at the SO_2 container.

Place hot towels around the container so that the heat will drive the gas out of the container and into the compressor. In order to check the amount of SO_2 that is going into the compressor, place the container on

scales and note the weight. Care should be taken not to apply too much heat to the container, as they are generally provided with safety plugs which fuse at about 160 deg. F.

ARCHIE L. FORGER.
Chief Electrician,
G. A. Head Electric Co.,
Laconia, N. H.

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Grouping of Wires in Conduit for Two-Phase System—I have installed some 3-in. conduit runs, to be used for two-phase power supply circuits. These conduit runs are about 25 ft. long. In them I wish to place 500,000-circ.mil cables and since it is possible to get only three cables of such size in a 3-in. conduit, it will be necessary to group the cables in two conduits. Will it be satisfactory to place the two A-phase cables in one conduit and the two B-phase cables in the other? In a three-phase system, this should not be done; hence, I am doubtful about doing it with two-phase cables. Would it be preferable to place one A-phase cable and one B-phase cable in each conduit? If so, which of the two B-phase cables should be placed in one conduit with the first A-phase cable? Please give me some information on these points.

St. Lambert, Quebec, Can. J. M.

Answering J.M., in alternating-current systems all the wires of a circuit must be drawn in the same conduit. A four-wire, two-phase system should be treated as two single-phase circuits, each circuit carrying one-half of the power at the same voltage.

Therefore, it will be satisfactory to place the two 500,000-circ.mil cables for phase A in one 3-in. conduit, and the two 500,000-circ.mil cables for phase B in another 3-in. conduit.

H. S. RAMSAY.
E. Kingston, N. H.

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It is safe for J. M. to group the wires in conduit for his two-phase system, for it is regular practice with a two-phase system to put two conductors of the same phase in one conduit; that is, the two conductors of the A phase in one conduit, and the two conductors of the B phase in another conduit.

It would not be safe to put one A-phase conductor and one B-phase conductor in one conduit, and the other A- and B-phase conductors in the other conduit. The reason for this is that the magnetic fields of the two A conductors in one conduit neutralize each other, with the result that the effect on the conduit is negligible.

This may be explained as follows: Let us call one wire of the A phase the going wire and the other the return wire. Then, if at any instant the magnetic flux around the going wire is in a clockwise direction, the flux around the return wire will be in a counter-clockwise direction because the same current is flowing in the opposite direction. Therefore the field of one wire neutralizes that of the other.

The foregoing is not true for a three-phase circuit, as the magnetic fields set up by two conductors in one conduit would not neutralize each other, and the resultant magnetic effect, since the currents in the two conductors are 120 deg. out of phase, would be impressed on the iron conduit, and thus cause heating, even in as short a run as 25 ft. The A-phase and B-phase conductors placed in one conduit would have a similar effect, since the currents differ 90 deg. in phase.

With currents of very low value the heating might not be serious, although there would be an added voltage drop in the conduit run due to the so-called inductive effect.

It is assumed in this case that the currents are on the order of several hundred amperes. With currents of such magnitude, serious heating would undoubtedly result if the conductors are improperly grouped in the conduit.

C. OTTO VON DANNENBERG.
Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

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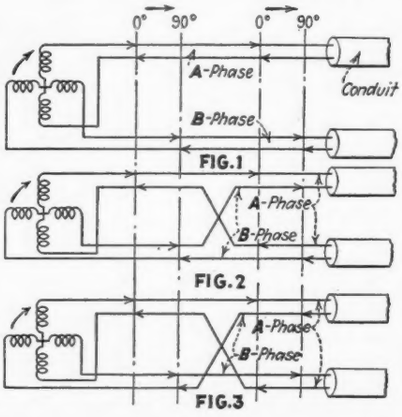
Answering J.M.'s question, it will be satisfactory to put the two A-phase cables in one conduit and the two B-phase cables in the other, as illustrated in Fig. 1 of the accompanying illustration, because a two-phase, four-wire system may be regarded as two separate single-phase circuits which have a difference in phase of 90 deg.

Should one A-phase cable be placed along with either of the B-phase cables in a conduit, heating of the conduit would result. If the two cables (one A-phase and one B-phase) were placed in one conduit so that the instantaneous direction of the current in each cable was the same, but differing in phase by 90 deg., as shown in Fig. 2, the heating of the conduits would be more pronounced than if the two cables were grouped so that the instantaneous direction of currents in each cable was opposite and differing in phase by 90 deg., as in Fig. 3.



These diagrams indicate the correct and incorrect methods of grouping conductors of a two-phase, four-wire system in two conduits.

Fig. 1 shows the correct method. Figs. 2 and 3 show an incorrect method, but the heating of the conduits in Fig. 2 would be more than in Fig. 3. Arrows indicate the instantaneous direction of current in the different wires.

With two-phase, three-wire systems and three-phase, three wire systems the three wires should be always run in the same conduit. ERNEST DICKINSON.
Kimberley, B. C., Can.

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In answer to the question by J. M., his suggestion to place two A-phase cables in one conduit and the two B-phase cables in the other conduit would work out satisfactorily.

If J. M. should undertake to operate them according to his second suggestion, placing one A-phase and one B-phase cable in each conduit, he would experience trouble in the way of low voltage, and the conduit would heat due to the transformer effect of the layout. A. C. BARKER.
Chief Electrician,
W. S. Libbey Co.,
Lewiston, Me.

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J. M. can use the same reasoning with a two-phase circuit as with a three-phase. A single conductor carrying an alternating current should not pass through a tube or other closed circuit of magnetic or conducting material. When such is the case, even with a steel pipe a few feet long, there is induced in the pipe or conduit a current which results in a definite loss of power.

The cable will carry direct current economically, as these losses continue for only a very short time while the circuit is being closed or opened. While the current is increasing or decreasing the magnetic flux surrounding the cable is expanding or contracting; that is, it is cutting through the surrounding material.

The action on a closed metallic circuit linked with this moving flux is the same as that in the secondary of a static transformer: A current is induced in the closed metallic circuit and, if the closed metallic circuit happens to be composed of iron or steel, the circuit is also magnetized and much energy is lost in reversing the magnetism with each cycle.

Looking in the direction of the flow of current in a cable, magnetic whirls are set up around it in a clockwise direction. If another cable is laid beside the first, but carrying a current toward the observer, this cable will tend to have a surrounding counter-clockwise flux; the resultant magnetism in a pipe surrounding the two cables will be very small, as the flux from one cable tends to neutralize that of the other, as they are moving in opposite directions.

With alternating current, at any given instant the resultant of the flux from the two conductors of one phase of the two-phase, four-wire system will be very small (theoretically zero), and that from three phase with the three conductors in one pipe will also be negligible.

In both cases the currents are moving in opposite directions and, therefore, the magnetism which links the conductors with the "secondary circuit" (pipe, and the like) is only that due to some unbalanced condition of the load, generating equipment or conductors. With two wires of a three-phase system in one pipe, this unbalanced condition is very serious and loss will result from hysteresis and eddy currents to such an extent as to make the installation unsatisfactory.

Therefore, the two A-phase conductors may be placed in one conduit and the two B-phase conductors in the other, for in this way the magnetic field of the conductors will neutralize each other. However, should one A-phase and one B-phase conductor be placed in the same conduit, twice as much heating of the conduit will be obtained as would be the case if only one

conductor were in a conduit. This is because the B-phase current lags 90 deg. behind the A-phase current; hence one current starts when the other ends and at no time do they oppose each other.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

Regarding J.M.'s question, it will be best to run the two A-phase cables in one conduit and the two B-phase cables in the other. By so grouping the cables, the magnetic flux around one cable is neutralized by that of the other cable in the same conduit, thus eliminating a large part of the induced currents and consequent heating.

Murphy, Idaho. ALEX BRENNER, JR.

* * * *

Use of Time Switches.—Many times I have felt that clock-operated time switches could be used to advantage in my plant, for instance on baking ovens and yard lights. Before installing these devices, however, I should like to obtain the viewpoint and experience of readers as to where these switches can be used to advantage around the industrial plant. Where are readers now using these switches to advantage and, also, where do they think they could use them if they were to install them at every point at which they would be of value?

Pittsburgh, Pa. K. E.

There seems to be some question in K.E.'s mind as to the reliability of time switches. Several years' experience with time switches of various sizes and makes under severe service and climatic conditions has convinced me of their dependability for a variety of purposes.

I have used clock-operated time switches here in Porto Rico mainly for two purposes. The first of these is for switching two wattmeters in and out of circuit, at definite, fixed hours, in connection with a two-rate service. This calls for a high degree of accuracy and reliability. We have between 30 and 40 time switches installed for this purpose, and have found them entirely satisfactory.

The second use to which we put them is for switching sign lighting on and off. Many of the time switches in this service are installed out of doors with consequent exposure to dampness and weathering incident to such location. In this service they eliminate the necessity of two visits each evening to the sign location to turn the lights on and off—a single visit once a week to wind the clock and check its setting now suffices. For severe service such as this, clocks have been developed with practically all parts, except the case, made of brass to prevent rusting. As a further protection, the case is waterproofed.

To insure reliable service from time switches it is necessary that the switch size be adequate for the current that is to be carried and interrupted.

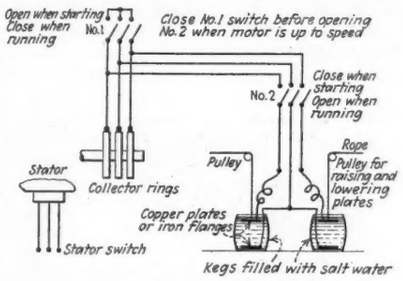
The reliability of time switches is evidenced by the fact that they have been used to control the operation of many small, automatic hydro-electric plants where their failure to function properly would be a serious matter in most cases.

FREDERICK KRUG.
Asst. to President,
Porto Rico Railway, Light & Power Co.
San Juan, Porto Rico.

Can Slip-Ring Motors Be Started by a Compensator?—I have several three-phase, 440-volt, wound-rotor, induction motors ranging in size from 25 to 150 hp. I have several spare compensators which I would like to use for emergency starting of these motors in case anything goes wrong with the present drum controller and secondary-resistance type of control. My plan is to short the slip-rings and start the motors with a compensator just as though they were squirrel-cage induction motors. Is this practicable? Is there any danger of damaging the motors? I would like to know the experience of other readers in this regard.

Chicago, Ill. W. J. A.

Referring to W.J.A.'s question, a wound-rotor motor may be started by a compensator after short-circuiting the rotor windings or the brush rigging at the collector rings. This method of starting will have no ill effects on the motor, providing it starts under a light load. If, however, the motor is loaded, the starting current in the stator will be several



This shows how a water rheostat can be arranged to start a wound-rotor, induction motor.

times normal, and excessive internal stresses may injure the windings.

A method that can be used to advantage for emergency starting is to employ the same switch for impressing the voltage on the stator, but use a water rheostat similar to the one shown in the illustration in place of the defective controller and resistances. Although this is a makeshift arrangement, it will give the motor the same starting and operating characteristics as before.

H. E. STAFFORD.
Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

* * * *

In reply to the question asked by W.J.A., I would say his plan is feasible but it has certain limitations; otherwise there would be no need for wound-rotor motors.

If a wound-rotor motor be short-circuited at the rings and the voltage applied to the stator through a compensator, its starting torque will be materially reduced and, if the motor is connected to a load that requires a high starting torque, the motor will fail to start. Should the load, however, be one which is easily started and the greater part of the load applied after the motor reaches full speed and is running on full line voltage, no trouble will be experienced. There is no more danger of damaging the motor by using a compensator than by using the secondary resistance method. The danger is that the motor will fail to start the load, because the necessary resistance method gives a very high starting torque.

In the past few years I have used the compensator method a great many times and the occasions have been rare indeed when it was necessary to raise the taps in the compensator to allow a higher voltage to be impressed on the motor during the starting period. However, on one occasion a few months ago when we tried this method of running a 100-hp., wound-rotor G.E. motor on a drive consisting of two long, heavy lineshafts to be started, we experienced a little trouble but after the compensator voltage was raised by changing to the next higher taps, the load immediately started and the motor ran satisfactorily. This method, if studied carefully, can be used to great advantage.

It happens many times that a squirrel-cage motor burns out and the only available spare is an idle, wound-rotor motor. By using the compensator method, changing of starting apparatus may be avoided and much valuable time saved. In case the loads that W.J.A. has to start do not require a high starting torque, he can easily use his wound-rotor motors with compensators and feel fairly confident that they will start the load.

LEE F. DANN.
Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

Regarding the question asked by W.J.A., I would say that it is possible to start a slip-ring motor by means of a compensator, but the design of the slip-ring motor is such that it has a weak starting torque when the rings are short-circuited; so some resistance should be connected across the slip-rings, before current is applied to the stator by means of a compensator, in order to give the rotor a greater starting torque.

With a slip-ring motor, the primary winding is similar to that of a squirrel-cage motor, but there is a difference in the design of the rotor windings. The rotor of a slip-ring motor has a phase-wound winding which consists of insulated conductors, similar in form to its stator winding, whereas with a squirrel-cage motor, low-resistance, short-circuited rotor bars are used. If the rotor of a slip-ring motor happens to be in a certain position with its slip-rings shorted, the rotor may fail to start when current is applied to the stator. However, if some resistance is left across the slip-rings during the starting period, the starting torque of the motor will be increased for a given amount of stator current. When the rotor has nearly attained its running speed, the rings can be short-circuited by a properly arranged switch. This is a poor method for operating a slip-ring motor, but it can be used in an emergency when the regular control equipment is out of commission.

R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

* * * *

Replying to the question asked by W.J.A., it was necessary a few months ago to replace a damaged drum controller that was used on a 100-hp., 440-volt, three-phase, wound-rotor motor.

This controller was damaged beyond repair and as this motor was an important one it was necessary to keep it in operation or shut down the plant. After looking around the shop, a compensator was found which had been used with a 175-hp. motor. This compensator was then connected to the damaged motor, and the three slip-rings on the motor were shorted by soldering a strip of copper across them. This motor is still being operated with the compensator and so far is performing well. WM. MCGUIRE.

Electrical Engineer,
Carbondale Machine Co.,
Carbondale, Pa.

* * * *

The method of operation proposed by W. J. A. is entirely practical. I have started slip-ring motors with squirrel-cage motor starters a number of times, and this method gives satisfaction so far as actual starting is concerned, although it cannot always replace the grid control on variable-speed motors or on motors that must start up gradually, such as hoist or crane motors. In order to start a wound-rotor motor with a compensator the rings or brush rigging must be short-circuited with a conductor of ample current-carrying capacity; otherwise, the power of the motor at full load may be reduced. A simple means of determining whether or not the wire that shorts the slip-rings has sufficient current-carrying capacity while the motor is running under heavy load is to short-circuit the slip-rings with a jumper wire also. If a spark results when the jumper is removed from the rings, this will indicate that the short-circuiting wire is too small. GRADY H. EMERSON.

Birmingham, Ala.

* * * *

In answer to W.J.A., it is practical to short-circuit the secondary leads of a wound-rotor motor and start it with a compensator, since a wound-rotor motor with the rings short-circuited has essentially the same characteristics as a squirrel-cage induction motor.

There are two reasons for the application of wound-rotor induction motors. First, with this type of motor the current drawn from the line in starting will not be more than 150 per cent of full-load current, in order to develop full-load torque. The second reason is that when more than full-load torque is required the wound-rotor motor will develop a maximum torque of approximately 250 per cent of full-load torque in starting, if the proper amount of secondary resistance is used.

A squirrel-cage induction motor started on the 70 per cent voltage tap of the compensator will develop approximately full-load torque in starting, and when full-load voltage is applied it will develop 200 per cent of full-load torque in starting.

A wound-rotor motor, having its secondary rings short-circuited, develops less starting torque for a given applied voltage than a squirrel-cage motor, because the greater self-induction of the wound rotor, the larger air gap and the distribution of the rotor windings, each has its effect in reducing the starting torque.

If the starting torque required is not great, compensator starting will be satisfactory; but when the starting requirements are heavy, full voltage may be required at the start and in this event the brushes may glow and burn during the starting period. When a wound-rotor motor is just about able to start its load, it would be practically impossible for this motor to start the load if the rings were short-circuited and the current applied through a compensator even if full voltage were applied to the primary windings.

When trouble is experienced in the starting of a heavy load by the compensator method, it may still be possible in some cases to start the motor satisfactorily by short-circuiting only two of the secondary leads, leaving the third one disconnected until the motor has partly come up to speed and then this third lead should be short-circuited. This method of starting has the effect of increasing the resistance in the secondary circuit. L. T. JOHNSON.

East Cleveland, Ohio.

* * * *

Changing Speed of Induction Motor.—What will be the horsepower and power factor of a 3-hp., Fairbanks-Morse, 1,200-r.p.m., 6-pole, 54-slot, standard factory wound, 60-cycle, 440-volt induction motor, wound with No. 16 wire in 54 coils with 28 turns per coil, span 1-9, when this winding is regrouped for eight poles instead of six?

Portland, Ore. P. M. W.

Regarding P.M.W.'s question, the method of connecting the coils is not given, but the following explanation will indicate what steps will be necessary to produce a satisfactory winding.

If the winding is to be connected for an 8-pole grouping, with 24 groups consisting of 18 groups of 2 coils each and 6 groups of 3 coils each, using the original connection, the rating would be reduced to about 2 horsepower. As the speed will be reduced from 1,200 to 900 r.p.m., the coil turns should be increased by a ratio equal to 1,200 ÷ 900 and the size of wire should be decreased.

Assuming that the old coils with the same number of turns and size of wire per coil which composed the six-pole windings will be used, regrouped and reconnected by the original type of connection into an eight-pole winding, the line voltage will have to be less, for the new line voltage should be $(900 \div 1{,}200) \times 440 = 330$ volts.

The effect of the coil pitch on the line voltage in this case can be disregarded, for with six poles the 1-and-9 pitch is one slot under full or 100 per cent pitch, as $54 \div 6 = 9$. For eight poles, the full pitch would be 1-and-7¾, as $54 \div 8 = 6\frac{3}{4}$. Then, as a 1-and-9 pitch will be 1¼ slots over pitch, and as over-pitch has the same effect as under-pitch, there will be only a ½ slot pitch difference between the six- and eight-pole windings, which difference is hardly worth considering.

It is evident from the above information that the coils of this motor cannot be connected in accordance with the original method, regrouped for eight poles, and then be put across a 440-volt line, as this procedure would necessitate operating the motor on 33⅓ per cent overvoltage. A. C. ROE.

Wilkinsburg, Pa.

Cause of Fuses Blowing on Transformers.—During a recent violent lighting storm, the fuses were blown on one of our 10-kva., 2,300/220-volt, single-phase transformers. This transformer supplies a small lighting distribution system. The transformer is protected by a pole-type lightning arrester. After the storm was over the fuses were replaced and the transformer operated satisfactorily. I shall appreciate any information that readers can give me on what caused these fuses to blow. I will be very much indebted to any reader who will advise me on this subject.

Wichita, Kan. Z. F. D.

The incident as outlined by Z. F. D. is not in the least an uncommon occurrence. This assertion will be borne out by the reports of the trouble department of any public utility company having any sort of an extended or extensive electric distribution system, especially after a lightning storm. The cause of the fuses blowing is undoubtedly due to a sudden inrush of current caused by a momentary rise of the voltage at the transformer terminals, which condition is due to the addition of the voltage induced on the line by a nearby lightning or heavy static discharge, to the normal line voltage.

Increase in exciting current in a transformer of modern design, due to an increase in the impressed voltage at the terminals, is in much greater proportion than the actual increase in voltage, depending, of course, upon the design of the transformer. I know of one instance where there was an increase of 100 per cent in the exciting current, while the line voltage increase was only 10 per cent. The voltage rise in question is of such extremely short duration in point of time, being of the order of millionths of a second, that the immediate effect or damage to the transformer may be negligible, particularly if, as in this case, a nearby arrester can discharge and thereby immediately relieve the line of the high potential condition.

If, on the other hand, no arrester or fuse were provided which could take care of such a condition, the voltage to ground would build up at the terminals of the transformer until a flashover occurred to ground, a bushing failed or the winding was punctured. As a rule in a transformer of modern design, the terminal bushings are designed to flash over before the voltage rise is sufficient to puncture them, and the end turns of the transformer nearest the line connection are more heavily reinforced with insulation. Hence, a failure from either of these causes is the least likely with modern apparatus.

The character of a lightning discharge seems to be such that it does not travel far in a highly inductive winding, such as a transformer, and the rise in voltage due to the choking effect of the winding quite commonly causes a flashover at the terminals, should the fuse not blow or partial relief be afforded by the discharge of the arrester. Experience indicates that the arrester should be located as close to the transformer line connection as it is possible to place it, on the same crossarm if possible, to make the reaction caused by the arrester discharge immediately effective to the transformer.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering and Management Corp.,
New York, N. Y.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Checking Up and Servicing Electrical Troubles

A SYSTEM of keeping a graphic record of trouble calls throughout our plant is based on making each trouble call count for so many points according to the importance of the operation and the time lost in the delay. The plant is divided into sections as, for instance, the hot mill, the annealing rooms, the tin house, the assorting room, and the like. One electrician is in charge of each department and his sole duty is to go over the electrical apparatus in his division and keep it in first-class condition. Each morning he is given the reports from the trouble shooters for the previous 24 hr. so that he can follow up all jobs.

The "Troublegraph" is plotted on a large sheet, the number of trouble calls received during the past 24 hr. being represented by a red line, which rises and falls in accordance with the amount of trouble. Hence, our slogan is, "Keep the red line down!" Every man in charge of a department has his name and department listed on this sheet and every morning the number of points chargeable to his department are marked up. If there has been no trouble his space is marked "0."

A meeting is held once a month in which every man participates, suggestions being offered by the men for improving operating and safety conditions throughout the plant. The "red line" also comes in for discussion, the men whose departments were responsible for running the red line up being asked to give an explanation and urged to do better in the future. Many things are brought to light in this manner, which otherwise might be missed. Careful inspection is made on all work done by the men, whether it is repair work or new work. Since instituting this system, our service troubles have fallen off one-half or more.

In order to give prompt attention to electrical troubles throughout the plant a 20-station annunciator has been installed in the shop, with push buttons to operate the annunciator located in almost every department of the plant. When a trouble shooter is wanted in any part of the mill, the annunciator indicates the location of the button station and very little time is lost in getting on the job, thereby saving the time and trouble of sending a man to the shop every time an electrician is wanted. The trouble shooter can also answer the call by pressing a button in the shop which lights a lamp at the button station, signifying that the ring has been heard.

We are planning to install red signal lights on the top of the main drive gears of each of the six 1,000-hp. drive motors with which the hot mill of the tin mill is equipped. There will be two whistles placed at these motors so spaced that either whistle can be heard in any part of the mill. This system is to be used in calling the proper attendant to any motor that needs attention.

C. H. SMITH.
Chief Electrician,
Sheet & Tin Plate Division,
Bethlehem Steel Co.,
Sparrows Point, Md.

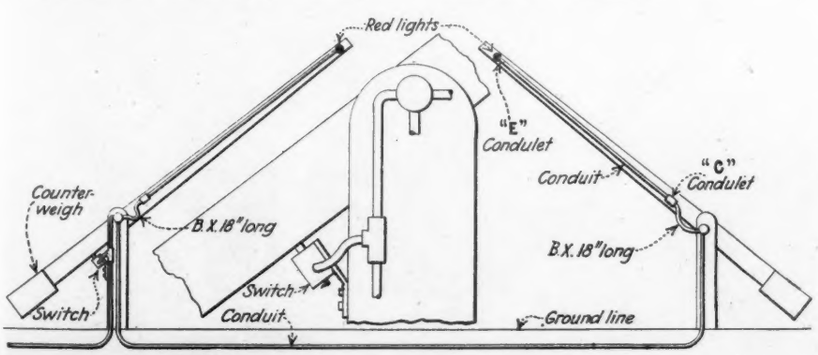
Controlling Warning Lights on Crossing Gates

RECENTLY a pair of gates guarding a railroad crossing were fitted with one red light each. It was desired to have these lights controlled so that when the gates were closed or down the lamps would be lighted, and automatically switched off when the gates were raised.

The wire on the gates was run in conduit and the joints in the underground conduit leading to the supply were carefully white-leaded to keep out water. For controlling the lights, a push switch such as is used in clothes closets, was installed as shown in the accompanying illustration. With this switch the circuit is open when the plunger is pushed in. Consequently, when the gates are dropped the lamp circuit is completed, but no current is used when the gates are up.

Chief Electrician, CHAS. A. PETERSON.
U. S. Gypsum Co.,
Alabaster, Mich.

When this crossing gate is up, the switch automatically opens and puts the red light out.



How to Use Relations Between A.W.G. Wire Sizes

THE American Wire Gage (formerly Brown & Sharpe gage) has a constant ratio between the different characteristics in the different sizes. The wire diameters vary in geometrical progression in the successive sizes; consequently, the cross-sectional area of one size is a constant times that of the next size. When the variations between the successive sizes or the constants are known, and also the properties of one size of wire per 1,000 ft., it is a comparatively easy matter to approximate very closely the properties of any other size of wire.

It will be remembered that No. 10 bare copper wire has a diameter of 0.1 in., a cross-section of 10,000 circ.mils, a resistance of 1 ohm per 1,000 ft. and a weight of 31.4 lb. per 1,000 ft. These relations are approximate. For calculations requiring exact values a wire table must be used.

It will be noticed that for each successive size all characteristics, except the diameter, increase or decrease in a ratio of 1 to 1.26, the ratio between the successive diameters being 1 to 1.12. The area, resistance, and weight are doubled or halved every third gage number and the diameter at every sixth gage number. For an increase of ten sizes the area, resistance and weight are multiplied or divided by 10. By the use of a slide rule it can be quickly noted that the cube root of 2 is 1.26 and that 1.26 squared is 1.59. The first constant is the ratio between successive gage numbers and the second or 1.59 is the ratio for every two gage numbers. It is suggested that 10,380 be remembered as the circ.mil area of No. 10 wire, because this will be the foundation upon which the whole wire table may be constructed. Any added refinement used at the start of the calculations will help to keep the error at a minimum. It is only necessary to extract the square root of the area in

Resistance of Copper Wire

Gage No.	Ohms per 1,000 Feet.		
0	.1		
1		.126	
2			.159
3	.2		
4		.25	
5			.32
6	.4		
7		.50	
8			.64
9	.8		
10	1.0		
11		1.26	
12			1.59
13	2.0		
14		2.5	
15			3.2
16	4.0		
17		5.0	
18			6.4
19	8.0		
20	10.0		

circular mils to find the diameter of the wire in mils. This is true because one circular mil is defined as the area of a circle having a diameter of 1 mil or 0.001 in.

By using the following rules, it is possible to find the characteristics of any size wire and the foregoing short cuts which are more or less commonly known should be kept in mind. To find:

(1) Pounds of wire per 1,000 ft.: divide the area by 330.

(2) Feet per lb.: multiply by 1,000 times the reciprocal of lb. per 1,000 ft.

(3) Ohms per 1,000 ft.: divide (10.37 × 1,000) by the area.

(4) Feet per ohm: divide area by 10.37; or multiply by 1,000 times the reciprocal of ohms per 1,000 ft.

(5) Pounds per ohm: divide lb. per 1,000 ft. by ohms per 1,000 ft.

(6) Ohms per lb.: divide ft. per lb. by ft. per ohm.

Basing our calculations on the fact that No. 10 wire has an area of 10,380 cir.mils, the several properties of different sizes of wire have been calculated on a slide rule and the results obtained will be tabulated as follows:

From Rule (1), 10,380 ÷ 330 = 31.4 lb. per 1,000 ft.

From Rule (2), (1 ÷ 31.4) × 1,000 = 31.8 ft. per lb.

From Rule (3), 10,380 ÷ 10.37 = 1,001 ft. per ohm.

The same result may be found by taking 1,000 times the reciprocal of the ohms per 1,000 ft., or (1 ÷ 0.999) × 1,000 = 1,001 ft. per ohm.

From Rule (5), 31.4 ÷ 0.999 = 31.4 lb. per ohm.

From Rule (6), 31.8 ÷ 1,001 = 0.0317 ohms per lb.

Suppose that a No. 6 wire is the next size that is to be calculated. The area of this wire may be found by using a short cut method. Thus a No. 7 wire has twice the area of a No. 10 wire and No. 6 wire has 1.26 times the area of No. 7 wire. The area of the No. 6 wire can now be calculated thus: 10,380 × 2 × 1.26 = 26,200 cir.mils. The other desired characteristics may be calculated in a manner similar to the above procedure.

The constant 10.37 that has been used in the above rules is the resistivity of annealed copper which is considered as having 100 per cent conductivity. This constant 10.37 is the resistance of a rod of copper 1 ft. long and having a cross-sectional area of 1 cir.mil at a temperature of 20 deg. C. or 68 deg. F. The values in this discussion are based on the resistance at 20 deg. C. and 100 per cent conductivity. The tables in the Standard Handbook for Electrical Engineers, pp. 241-244, were used as a standard.

Another easy method of approximating the number of ohms per 1,000 ft. of wire is given in Circular No. 31 of the Bureau of Standards. Starting with the resistance per 1,000 ft. of No. 0 wire as 0.1 ohms, No. 1 wire has a resistance of 0.126 ohms and No. 2 wire has a resistance of 0.159 ohms. Thus, if occasion requires, it is easy to construct a table showing the resistance of different sizes of wire.

CHAS. F. CAMERON.
Rock Springs, Wyo.

Draining Static Electricity from Color Printing Press

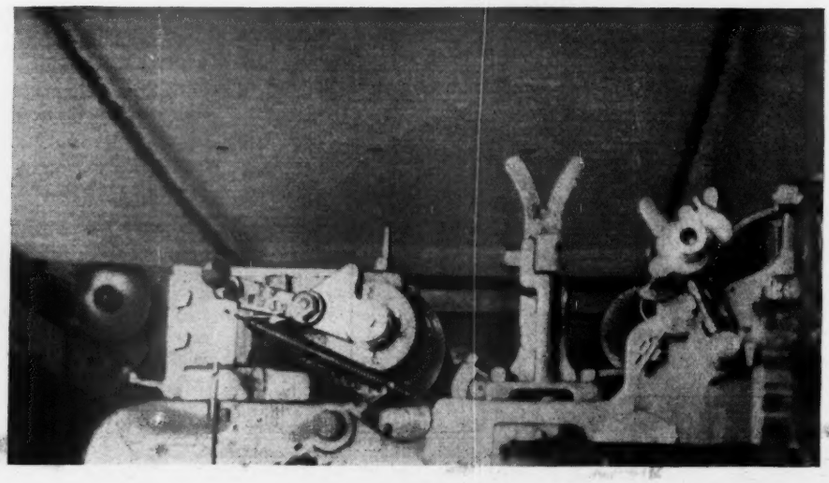
THE operators of a large color printing press experienced considerable trouble due to static electricity.

Static electricity may be induced by friction, and hence sometimes spoken of as frictional electricity. By waving a sheet of paper in the air enough static electricity can be generated to be detected by delicate instruments. In the case of a printing press, the continuous travel of the paper web at 550 to 600 ft. a minute causes the collection of heavy charges of electricity. At times the pressure on the paper due to static is so great as to deflect it from its normal course of travel and thus cause trouble.

To eliminate the static on this press, bare copper wires were first placed at a right angle to the travel of the paper web, about ½ in. below the paper, and grounded to the press frame. This gave some relief from the static but it was not a cure. Then, Christmas tree tinsel cord of about 1-in. diameter was tried in place of the bare copper wire, with results that were remarkably successful.

Then, two No. 14 solid, bare copper wires were wound together with the Christmas tree tinsel and placed 1 in. below the paper web, as shown in the accompanying illustration, and grounded to the press. The copper wire provides the necessary mechanical strength to stretch the tinsel tightly across the press and make a satisfactory ground connection. This arrangement has eliminated all static trouble.

Engineer, E. H. LAABS.
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

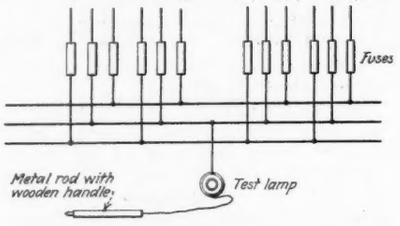


Two copper wires, wrapped with tinsel and grounded on the press, were placed below the paper web, to drain off the static.

Simple Method of Locating Blown Fuses on Panel Board

A PERMANENT test lamp will prove to be a saver of time, as well as the annoyance of hunting for a portable tester, on an installation where several sets of lighting fuses are grouped together. The connections for such a permanent test lamp are shown in the accompanying diagram.

In making up this tester, one terminal of a porcelain receptacle is connected directly to the grounded main conductor. To the other terminal of the receptacle is connected a suitable length of flexible cord, terminating in a metal rod. This rod should be fitted with a wooden handle having an eye screwed into its upper end. In practice, the rod is simply grasped by the handle and touched to the different fuse ferrules until the defective fuse is found. The screw-eye in the handle is for the purpose of hanging the rod up when not in use. JAMES P. MARSHALL.
Providence, R. I.



With a permanent test lamp connected as shown a defective fuse may be found by touching the rod to the different fuses in turn.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Improperly Bored Bearing Causes Trouble

AFTER new bearings had been installed a 20-hp. motor in a woolen mill would not get up to normal speed. Even the operators on the group of machines driven by the motor noticed the lack of speed and called attention to it. Investigation traced the trouble down to the new bearing at the pulley end of the motor. The repairmen in the mill made it a point to keep one, and sometimes two, bearings ready for each of the motors. When the bearings got worn so that there was danger of a rotor dragging, new ones were put in and the worn ones sent in to the maker for rebabbitting or exchange. This is the most economical practice, particularly in small plants which do not have the proper facilities and but little of this type of work to do.

In this case the new bearing had not been bored true with the outside of the shell. In making the replacement, the mechanic had noticed that the head had gone on with difficulty; so he had pulled it off, micrometered the shaft and bearing, found them all right, and then made sure that all surfaces were clean and free from bruises before assembling again. The bearing seemed to be stiff, but the man was alone and he had not thought it worth while to call the chief, as he believed that the bearing would run itself in, which it did not do.

Emergency measures were necessary in order to keep the motor operating. The hole had been bored diagonally through the shell through some shop laxity that would not ordinarily be anticipated. It was necessary to scrape out the bearing, halfway in from each end on two opposite sides, until the shaft turned freely. This gave sufficient bearing surface to keep the motor going until a new bearing was secured.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Flexible Drive Solves Fan Operating Problem

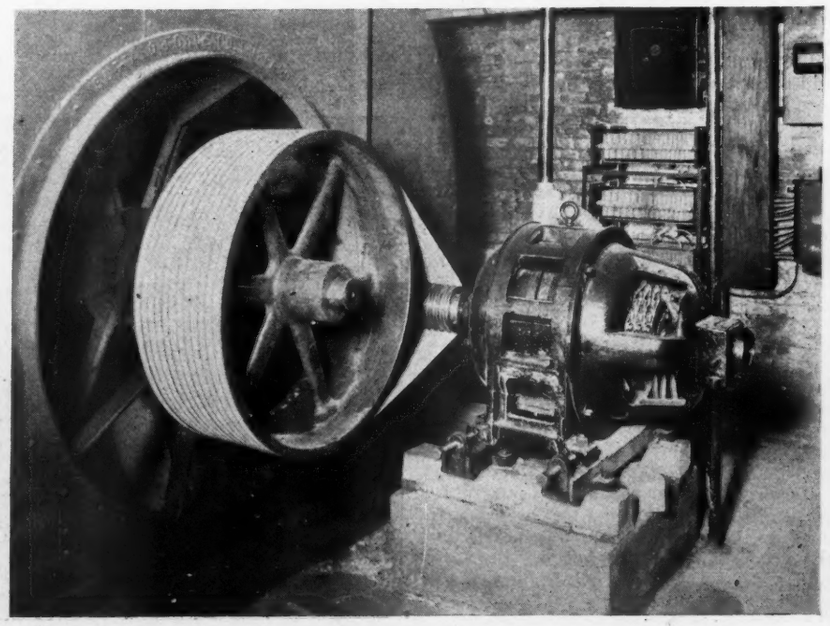
IN MANY cases a satisfactory type of drive for one class of service will not operate so well under different conditions. Probably one of the most severe service conditions for many drives is shock load. Mechanical drive elements that do not provide sufficient flexibility to take care of the shock are not only subjected to the effect of the shock, but pass it on to the bearings. As a result, the mechanical element of the drive either breaks or is hammered to pieces, unless a unit of extra size or strength is provided, or the next weakest link of the drive gives away.

In such cases the inclusion in the drive of a flexible unit that will absorb this shock has solved the transmission problem in a number of instances. For example, a brick plant recently installed a steam engine to drive a large exhaust fan. The engine and fan were connected on close centers by a metallic, inflexible drive. Due to the sudden changes in load, the fan would run ahead of the engine at times and then, as the load came on, would tighten up with a snap, with the result that the drive would soon be pounded to pieces. A flexible drive of the Texrope type (Allis-Chalmers Manufacturing Co., Milwaukee, Wis.) was installed with good results. Sudden load changes are absorbed by the flexible drive with little or no bad effect, it is stated. The change also provided considerable relief for the engine and fan bearings.

In making changes such as this in a drive, care must be exercised to see that flexible units of sufficient size are used and that they are strong enough to absorb the overload due to the shock. This means making an allowance in the rating. Where the shock is severe, it is seldom sufficient to substitute any of the various types of flexible drive units without providing the necessary overrating.

Still another advantage of flexible drives on fans is their silent operation, which is an important consideration when the fan is located near factory or other offices, in schools, theaters, and so on. The accompanying illustration shows such a drive with a 50-hp. high-speed motor, connected to a low-speed fan by a ¾-in. Texrope belt. The sheaves are 6 in. and 38 in. in diameter on motor and fan respectively. Shock load is not such an important consideration in this particular fan drive, but any small shock due to slight fluctuations in the load would add to the noise of operation if not absorbed. The motor is mounted on blocks insulated from the foundation, as shown, to absorb the motor hum and so decrease the noise.

Silent, flexible Texrope drive connecting high-speed motor to low-speed fan.



Ball Bearing Hangers Give Over 10-Yr. Life in Flour Mill

THE ball-bearing hangers installed in our mill over ten years ago have been in use 24 hr. per day practically every working day since that time. The original bearings are still in the hangers and with the exception of two hangers out of 55 we have had no bearing trouble in that period. The ball-bearing hangers were installed in order to reduce the friction load and to get away from the oil leakage that goes with the use of the old-type bearings. These 55 hangers are installed on six lineshafts

which drive the rolls, packing machinery and other equipment in our flour mill. The shaft sizes vary from $1\frac{7}{16}$ to $3\frac{7}{16}$ in. and transmit a total of 225 hp. at about 240 r.p.m.

Power is saved through the reduced friction. As our machinery is operated 24 hr. per day the power economy amounts to a considerable figure in the course of a year. If the old bearings were used the power required would probably be at least 10 per cent more than with the SKF ball bearings with which the plant is now equipped.

Savings Effected by Installing 55 Ball-Bearing Shaft Hangers

Power—22.5 hp. × 24 hr. @ 1¼c. per hp.-hr. × 300 days	$2,025.00
Labor—greasing and wiping	
With babbitt bearings—	
5 hr. @ $0.50 per hr. × 300 days	$750.00
With ball bearings—	
10 hr. @ $0.50 per hour	5.00
	745.00
Saving per year in power and labor	$2,770.00

Another item of saving, though not so large, is the reduction in greasing and wiping labor. We grease the ball-bearing hangers twice a year and the total time spent per year in this work is one day. Under former conditions about 5 hr. per day were spent in greasing and wiping. The elimination of oil drippings from bearings is another advantage obtained. No drip cups are required and it is much easier to keep our plant clean. It is very seldom that our new bearings drip any oil in spite of the fact that the original felt washers are still in the hangers.

The old type of bearings on some of our machines throw oil on the belts. On one such machine the life of small belts is only eight months on account of the deteriorating effect of the oil, whereas these belts should last eight to ten years.

Because of the satisfaction given by the ball-bearing hangers, we purchased eight Fairbanks-Morse motors equipped with SKF ball bearings. They vary in size from 5 and 20 hp. with a total of 110 hp. and are driving conveyors, fans and other equipment. Some of the motors are direct-connected to their loads and others drive through belts and silent chains. To date we have not had any bearing trouble with them. We also use ball bearings on seven fans. On one fan the reduction of friction load has reduced the total load and given an appreciable higher speed of the fan. This particular belt drive required much attention previously, but has been functioning very well since the ball bearings were put in.

In the new addition to our plant we have used practically no babbitt bearings and have specified ball bearings on many of the machines; although ball bearings cost more than the old type of bearings they are easily worth the difference in cost, we believe. A total of $2,770 a year is saved by these bearings on lineshafts alone as shown by the accompanying tabulation.

A. G. BECKMAN.
Superintendent,
Pioneer Flour Mills,
San Antonio, Texas.

Individual Drives Give Special Machines Increased Operating Flexibility

EVERY thinking industrial operating man will find that a separate decision as to the type of drive, that is, individual or as one of a group, should be made in connection with each machine. There are cases, for example, where it is advantageous to intersperse individually-driven machines among those which are group driven. The method of driving used in connection with the two small machines shown in the accompanying illustration, and which are used only occasionally, is worth considering in many instances.

Originally these two machines were mounted so that they could be driven from overhead. Their location, however, was not the most convenient for the work; also, they were used only infrequently and were in the way about 75 per cent of the time.

The manufacturing policy in this plant is to handle the parts as little as possible, which means, for them, to finish the parts where they are rather than to have one department do all the milling, another all the drilling, and another the assembling. In the line-up shown in the illustration, small steel pieces are run off the milling machines at the right, from which it is but a step for the operator to place them on the bench, burr off the work, and gage it while the next cut is running.

Certain products which come from these machines have subsequent operations upon them, such as threading, riveting and light bench work which, in volume, can be run through in about one week out of every four. This extra work requires two additional machines. The former practice, as stated, was to have these permanently mounted in place and driven from overhead countershafts.

The type of drive should be selected to give the best operating conditions, as in this case.

Formerly these machines were group-driven from overhead countershafts. However, as they were used only on certain jobs lasting about one week in four, it was thought best to drive the machines individually so that they could be removed when not in use to provide more floor space for other jobs.

Floor space was so crowded that the management wished to make other arrangements and asked the mechanical department to find a better way of handling the work. This was eventually done by rearranging the machines to individual drives by means of the two fractional horsepower motors, as shown. Now, when the time comes to do this part of the work, the two machines are brought out from storage and placed in line so that the machines perform their tasks in the proper sequence as the part moves along.

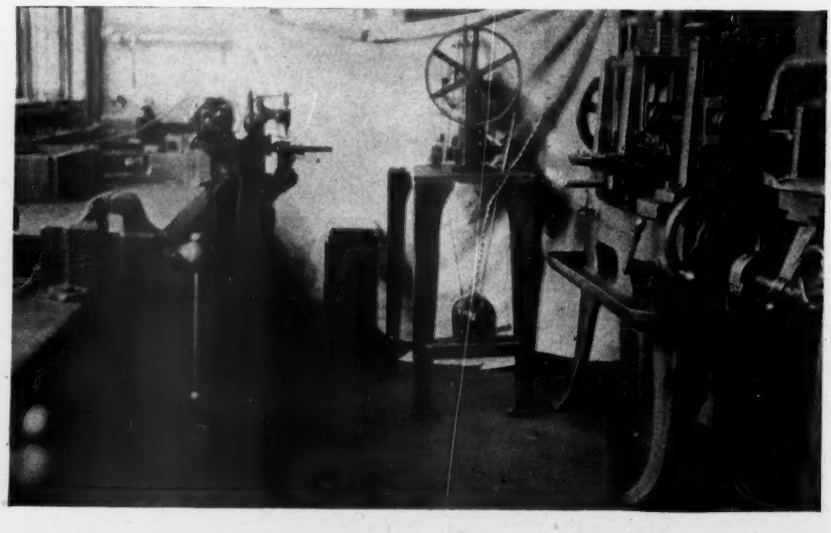
For example, after the bench work is done, the boxes of parts are shoved along to the operator of the little riveting hammer, which stands alongside the bench, who inserts the $\frac{7}{16}$-in. rivet and spins the head over. This machine is driven by a $\frac{1}{3}$-hp. motor which is mounted on a bracket at the rear. The drive is by a short tape belt, sewed endless. A light socket furnishes power.

From the riveter, the parts are handed over to the tapping machine in the center, on which a $\frac{1}{4}$-hp. motor drives the mainshaft. This machine is subjected to rather heavy service, which consists of tapping a $\frac{3}{8}$-in. thread through $\frac{3}{8}$ in. of cold-drawn steel.

When the run of work is over, the plugs are disconnected and the machines trucked back to storage. It does not take over 10 min. to install or remove them. The floor space formerly given over to these small tools is then occupied far more profitably by a heavier machine tool, or is used for other purposes.

In this same small plant six machines are now arranged in this way. Besides the immediate saving in floor space, the machines can be placed in better working positions for light and handling of product. Also, there is a noticeable power saving, because in every case the losses from the lineshaft to the machine were more than the useful power required. In addition, there was a continuous loss when the machines were not producing, which is now entirely avoided. The motors used are all either of $\frac{1}{3}$- or $\frac{1}{4}$-hp. rating and in one instance the same motor is used for two machines.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.



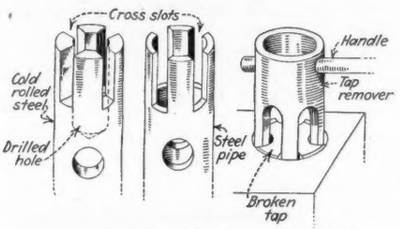
In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

How to Make Handy Tool for Removing Broken Taps

IN MANY cases a tap which breaks off while being used is very difficult to remove because burrs will frequently make it difficult to turn it in either direction.

The tool shown in the accompanying illustration can easily be made from steel pipe or cold-rolled steel bar. With its help the troublesome, broken tap can be removed without difficulty.



This tool will make it easier to remove a broken tap.

A tool of this kind can be used to remove several different sizes of taps. By inserting the end of the tool into the tap, as shown in the illustration, the latter can be alternately turned to the right and left until the burrs are broken up or pushed aside so that the broken tap can be removed.

Washington, D. C. G. A. LUERS.

Method of Insulating Coils for Semi-Closed Slot Motors

THE service we have obtained from rewound, semi-closed slot stators for a.c. motors has not been very satisfactory until recently, owing to the difficulty of properly applying varnish to the coils after the stator has been rewound. The absence of an impregnating tank and a baking oven in our repair shop has made it necessary for us to devise a method of varnishing the coils before they were installed in the stator.

Several kinds of varnish were tried before one could be found which was suitable for this work, owing to the tendency of the coils to be sticky. This stickiness caused the various turns to adhere to each other and made their installation in the slots almost impossible.

At present when we have a semi-closed slot stator to rewind, the coils are wound in the shape of loops on an adjustable form. The ends of the loops are then taped for a short distance and the coils pulled to shape. If too much tape is used at the ends of the loops, it will interfere with placing the coils in the stator slots. On the other hand, sufficient space must be covered with the tape to enable the coil to hold its proper shape after it is pulled. As soon as all the coils are pulled to shape, they are thoroughly heated to a moderate temperature. While they are still warm, they are dipped in a small tank of varnish and allowed to remain there until completely filled or saturated. When all signs of air bubbles have disappeared, the coils are withdrawn from the varnish container and hung up to drain off the excess varnish. After the draining-off process is finished, the coils are removed to a warm place and left hanging up until they have been thoroughly air dried. The time required to dry the coils properly is 24 hr. They are then ready to be installed.

The time that is required to install the coils by using this method is slightly more than by the old method, but the final results are well worth the time and added expense. Before placing the coils in the slots, the turns are given a coating of parowax. The parowax gives the coils a nice, smooth surface and also causes the turns to pass through the openings to the slots much easier. It is a well-known fact that an application of parowax is beneficial on all winding jobs and most winders make extensive use of it. Coating the coil turns with parowax helps to separate the turns of the coils from each other, but before placing them in the slots, the ends of the loops are taped again for some distance up into the slot itself, in order to be sure that there is no weak point in the insulation near the edge of the laminations.

After the coils are placed in the slots, each individual coil is tested to ground at 2,200 volts before any end connections are made, thus safeguarding against grounds while the motor is operating at its rated voltage. As soon as these tests are completed, all coils are assembled and placed, all of the top wedges are put in, and the remaining end connections are made. When the final tests have been completed the stator is placed on a heating coil and left there for a day or two at a moderate temperature before the finishing coats of varnish are applied.

The final coats of varnish are applied with a De Vilbiss air spray gun, using 40 to 50 lb. of air pressure, to force the varnish into all small crevices and thoroughly seal up the winding. Usually two coats of the varnish are applied with the spray gun, but if the motor is to be used in a particularly damp place, or where it will be exposed to acid fumes, four coats should be applied. Each coat of varnish should be allowed to dry 8 to 16 hr. before the next one is applied, in order that each coat will make a good, hard finish without the application of too much heat.

Motors wound in this manner are giving excellent service in places where moisture and acid fumes are present. Some of our motors that are direct-connected to acid pumps are giving splendid service, even though such service is hard on a motor.

After considerable experimenting, we have standardized on an armature varnish that is used on all of our work. This varnish is manufactured by an English company and is sold under the trade name of Ohmaline. There are several grades of this varnish, but for our requirements, including use with a spray gun and under difficult drying conditions, Ohmaline No. 68 has given by far the best results. For our particular work, no other make of varnish seems to give equal satisfaction.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

Armature Baking Oven Located Out of Doors

MANY electric railway companies realize the advantage of the dipping and baking treatment for armature and field coils, but some are denied its benefits because of the lack of available space in the armature room, or even in a convenient location for installing the necessary equipment. This was

Outdoor electric oven used for baking armature coils.

A truck is used to carry the work from the shop and to hold the coils during baking.

the situation that confronted us, but we solved it by means of an electric oven, which was placed within 10 ft. of the armature room outdoors, a feat made possible because the operation and control of the oven are entirely automatic. A roof was built over the oven for the protection of the blower motor, which is located on top of the oven, and provides proper air circulation.

The electric oven installed is of Westinghouse manufacture and is equipped with automatic control and operated from a 600-volt d.c. power supply, although it could be arranged for some other voltage if desired. The inside dimensions are 8 ft. wide, 7 ft. deep and 6½ ft. high. Six large armatures can be accommodated at one time. The baking temperature is 230 deg. F., insulation being provided on the oven to prevent excessive heat radiation to atmosphere outside of the oven.

The coils are transported to and from the armature room by means of a four-wheel truck. Before an armature is dipped, all dirt is removed with clean compressed air. Then the armature is heated at a temperature ranging from 95 deg. C. to 105 deg. C. for a period of 12 to 24 hr., depending on the size. This drives out all moisture and warms the armature for dipping. The armature is dipped in an insulating varnish, pinion end down, by means of a chain hoist until the varnish level reaches the neck of the commutator, and is allowed to soak until all bubbling ceases.

After draining at room temperature, the armatures are placed on the oven truck in a vertical position so as to avoid pocketing of the varnish, and baked at 95 to 105 deg. C. for 48 to 72 hr. depending upon the size.

Field coils are treated in practically the same manner. R. C. TAYLOR.

Supt. of Equipment,
The Michigan Railroad Co.,
Albion, Mich.

How A.C. Motors With Defective Coils May be Kept in Service

IN THE event that an alternating current motor has a defective coil, the motor can often be kept in service without rewinding the coil. When the type of connection will permit, both the faulty coil and the one that is diametrically opposite the damaged one, in the same phase, should be cut out of service. If it is also desired to balance the phases, two coils must likewise be cut out of each of the other phases, and the coils that are cut out should have the same respective positions in their phases as the coils cut out in the first phase. Cutting out coils will lower the operating voltage of the motor by an amount depending on the number of slots and of phases in the motor.

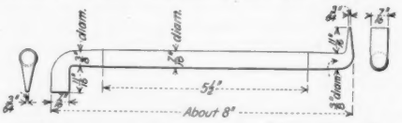
For example, consider a three-phase motor having 96 slots. The percentage of voltage reduction may be determined from the formula: (Number of coils cut out × 100) ÷ (Number of coils in the motor ÷ number of phases) = 2 ÷ (96 ÷ 3) = 6¼ per cent reduction in voltage. The reduction in voltage of a three-phase motor having 72 slots and 72 coils will be (2 × 100) ÷ (72 ÷ 3) = 8⅓ per cent. Should a motor have 54 slots and 54 coils, the voltage reduction would be 11.1 per cent. In this case the reduction in operating voltage is too great and would cause the motor to run hot. The above formula will apply equally well to two-phase motors.

Muncie, Ind. GEORGE CROPPER.

Simple Screwdriver for Use in Close Quarters

WE ARE all familiar with the offset type of socket wrench used to remove nuts or capscrews located in cramped or inconvenient places, but a screwdriver that will turn machine screws which are similarly located is not so common.

Some time ago we had occasion to remove some machine screws from a coupling flange where it was impossible to use a screwdriver owing to lack of space; so we devised a special screwdriver which was forged and made up in accordance with the accompanying diagram. The straight part of the screwdriver, 5½ in. long, can be knurled to allow a better grip on it.



This screwdriver will be found handy for turning screws that are hard to reach.

One end of the screwdriver is shaped to fit into a screw-head slot that runs in the same direction as the shank of the screwdriver, and the opposite end is finished to fit into a slot that runs at right angles to the shank. After it was hardened and tempered, this special screwdriver proved to be very handy for turning many inaccessible machine screws. DAVID FLIEGELMAN.

Worcester, Mass.

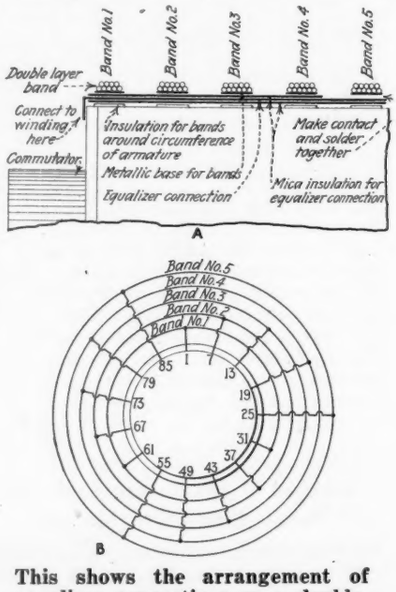
Rewinding Double-Commutator Type Armatures

IT IS occasionally necessary for us to rewind armatures of the double-commutator type and, due to the high speed at which these armatures rotate, their construction is generally such that no space is available behind the commutators to accommodate equalizer rings, which are quite necessary, as the armatures are lapwound.

The armature of a generator which was recently rewound was lapwound and had six poles, 90 coils and slots, and 90 commutator bars per winding. The coils were of the half-coil type, and were made of strap copper. There is, necessarily, between two adjacent commutator risers, a back connection clip which includes 90 commutator risers and 90 clips; so the equalizer connections for each ring have to be spaced 90 ÷ 3 or 30 slot connections apart, which winding pitch results in a coil span of 1-and-31, for a six-pole winding.

The method of assembling the connections is in accordance with the following procedure. The respective positions of the coil bands, insulation of equalizer connections, and commutator are indicated in *A* of the accompanying illustration. First, we put the insulation strips for the five bands in place around the circumference. Then the equalizer connections, which are strips of sheet copper, are laid across the core from the back connections of the coils to the proper band, being careful to insulate them properly on top and bottom with sheet mica. When this is done, a sheet of strip copper is laid over the band insulation and equalizer connections with the assurance that only the proper equalizer connections come in contact with this strip, after which the band wire is wound on in a double layer. This strip is then soldered to the band and equalizer.

As there are five bands around the core, as shown at *A*, which are necessary by reason of the high speed of the armature and the comparatively large diameter of the core, these bands can be used as equalizer rings; so there will be 3 × 5 or 15 connections to make between the windings and the rings as indicated at *B*. Since it is necessary to make 90 back connections and 15 equalizer connections, the number of coils from one equalizer connection to the next will be 90 ÷ 15, or 6, resulting in a coil span of 1-and-7. The coils that need to be connected to the bands are, *1*, *7*, *13*, *19*, *25*, *31*, *37*, *43*, *49*, *55*, *61*, *67*, *73*, *79* and *85*, as indicated in diagram *B*. These coils should be connected to the bands as follows: Coils *1*, *31* and *61*, to band No. 1; coils *7*, *37* and *67* to band No. 2; coils *13*, *43* and *73* to band No. 3; coils *19*, *49* and *79* to band No. 4; and coils *25*, *55* and *85* to band No. 5.



This shows the arrangement of equalizer connections on a double-commutator-type armature.

The method of insulating and connecting the equalizer is shown in *A*. Diagram *B* indicates which bands and coils are connected together.

The equalizer connections are fastened to the coils by bending the equalizer connections over the edge of the coil connectors and drilling and tapping them for a small-sized screw, after which all connections are also soldered.

Brooklyn, N. Y. MICHAEL REUTER.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Melting Pot

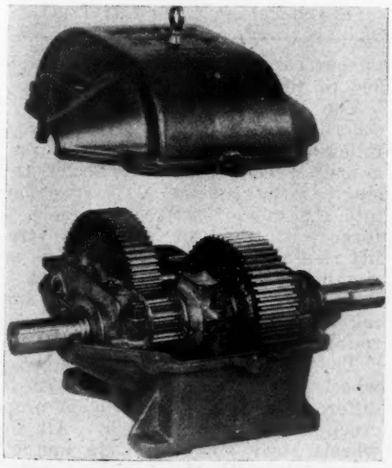
GREATER safety and convenience are two features being claimed for a new electric solder pot, which has been placed on the market by the Electric Engineering Co., Inc., 11712 Atlantic Ave., Richmond Hill, N. Y. This solder pot, known as the Electro Melter, is adaptable to maintenance work in large buildings and factories, and in fact, wherever solder, lead or babbitt has to be melted. This pot, which can be supplied in two sizes—15 lb. and 30 lb. solder capacity—is wired for operation at four different temperatures and can be operated on 110- or 220-volt alternating or direct current.

Speed Reducer

THE Palmer-Bee Co., Detroit, Mich., has recently put on the market a new design of speed reducer. This mill-type speed reducer comprises a set of spur gears mounted on the main drive shaft, the high-speed shaft, and the countershaft, respectively. The high-speed and main driveshafts are axially concentric, and the power is delivered to the driven unit directly on a line with the point where it is received. The machine-cut gears are unusually large, it is claimed.

The bearings are long, cast integral with the bottom half of the casing, and are bronze bushed, as may be noted from the accompanying illustration. All moving parts are lubricated by a patented oil bath, splash and gravity feed system. The entire mechanism is enclosed in an oil-tight and dust-proof housing of rugged design.

The casing is split horizontally on the center line of the shafts, and the upper half, or cover, can be easily removed for inspection of the gears or changing the ratio. The bearing caps are independent of the casing, so that removal of the cover does not disturb the bearings.



New design of Palmer-Bee mill-type speed reducer.

Small Safety Switch

ANNOUNCEMENT is made by the Trumbull-Vanderpoel Electric Mfg. Co., Bantam, Conn., of the marketing of the new 77 safety switch. This is a small, compact unit for direct application to the control of motors up to ¾-hp. rating driving light machinery, such as commercial sewing machines, electric pumps, and so on. The manufacturer states that the switch is only 3¼ in. wide, 5 in. high, and 2⅛ in. deep, not including the bulge in the cover. It is a double-pole, 30-amp., 125-volt polarized switch arranged for single-plug fusing. It is stated that because of the special construction of the end plate, which can be easily removed, or replaced with the switch in position, and is shown just above the illustration of the switch, the wiring and installations are considerably simplified and greatly speeded up.

The New Trumbull-Vanderpoel "77" Safety Switch

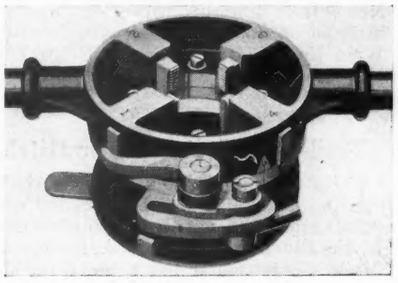
Dry-Plate Air Filter

DEVELOPMENT of a new air filter has been announced by the American Blower Co., Detroit, Mich. The description and principle of operation of the filter are given by the manufacturer as follows: By means of this new filter, which is of the dry-plate design with hairlike tentacles for the arresting and retention of dust and dirt, dust-laden air is divided into a series of small jets which strike the flat, filament-coated surface of the plates, the dust being projected against the filament, seized and retained. The air, changing its direction and rebounding from this surface, flows through to the next plate and is carried through ten successive dust-removal operations of this type. As dust builds up on these flat surfaces each preceding layer acts as a retentive member, the dust first attracted being itself the principal arresting and retaining factor for the succeeding particles. In this way the use of adhesives is avoided, it is stated.

The outstanding advantages of this type of air filter are said to be that it is impossible to clog this filter, that it does not require oil or other adhesives which have to be changed from time to time, that it has a constant effect and constant efficiency, and that dust builds up on dust and does not get in the line of air flow.

Adjustable Diestocks

MARKETING of the No. 70 Series of Beaver adjustable diestocks is announced by The Borden Co., Warren, Ohio. This series is adapted for power drive and is made in five units which range in capacities from ¼ in. minimum to 2 in. maximum, in plain and ratchet types. The unit shown in the accompanying illustration is of the plain type. The dies may be thrown open after the thread is cut, thus saving backing off by hand.



Borden adjustable diestock.
Borden adjustable diestock

Each tool threads several different sizes of pipe without changing dies or bushings and left-hand threads may be cut in the same tool by inserting left-hand dies, according to the manufacturers. The die adjusting cam is beneath the dies. It is stated that the three-jaw universal chuck quickly and accurately centers all sizes of pipe; also, that no locking is necessary.

Wide Range Welding Blowpipe

THE outstanding feature claimed for the new Prest-O-Weld W-101 blowpipe, recently offered to the trade through jobbers by the Oxweld Acetylene Co., 30 E. Forty-second St., New York City, is that it is designed so that the oxygen and acetylene enter the inlets at about equal pressure and are thoroughly mixed in a simple mixing chamber. The mechanical efficiency of this chamber, it is stated, insures intimate mixing of gases under all working conditions, eliminates waste of gases, and saves the time of the operator in maintaining the neutral or working flame.

This new welding blowpipe is of all brass construction and is said to be simple in design. It is screwed together on metal-to-metal seats, with no soldered or packed joints, to facilitate ease of disassembling and reassembling when minor repairs are necessary.

Stems for the W-101 blowpipe are made in three lengths, 4, 9, and 19 in. long, each of which, in turn, is made in three angles, 45, 60 and 90 deg. By un-

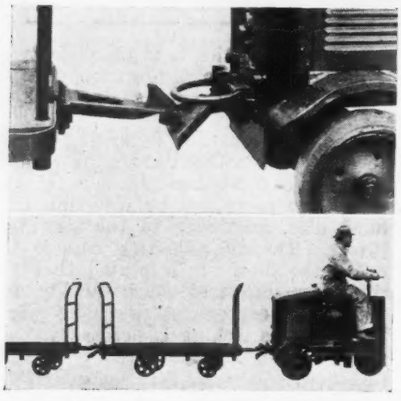
locking one union nut, any one of these stems can be fitted to the handle part of the blowpipe. This feature greatly increases the adaptability of the blowpipe to the physical peculiarities of the work in hand and to the preferences of the operator. The over-all lengths of the blowpipe with the different stems are 15, 20 and 30 in.

The ten interchangeable tips offered with the blowpipe are constructed to withstand the severe service to which welding tips are usually subjected.

The entire W-101 welding outfit complete includes one type R-101 oxygen regulator equipped with 100-lb. and 3,000-lb. gages; one type R-103 acetylene regulator equipped with 30-lb. and 350-lb. gages; 12½ ft. of ¼-in. green oxygen hose with standard I.A.A. couplings; 12½ ft. of ⅜-in. red acetylene hose with standard couplings; one pair of No. 6 fiber goggles, wrenches, and an instruction booklet. The new Prest-O-Weld line also includes the C-101 cutting blowpipe.

Trailers with Automatic Hitch

THE accompanying illustration shows the Clark caster wheel trailer with automatic hitch which is manufactured by the Clark Tructractor Co., Buchanan, Mich. This trailer has a platform size of 3 ft. x 6 ft. and it is 13½ in. from the ground to the top of the platform. The



Caster trailer train connected with Clark automatic hitch which is shown in detail in the upper illustration.

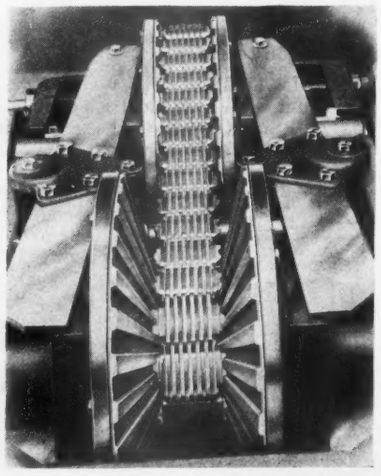
platform is made of hardwood 1¼ in. thick running crosswise on the trailer and held in place by hardwood bevel sills which are reinforced by steel plates 3 in. wide x ¼ in. thick.

Two 2-in. x 2-in. x ¼-in. angle-iron girders run lengthwise underneath the platform, for additional support to the platform board, and also act as supports for the front caster wheels. Eight steel pockets (two on each of the four sides of the platform) are bolted to the under side of the platform for holding in place rails or racks made of 1-in. pipe. The rear axle is supported on heavy steel brackets and reinforced by two additional supports from the angle-iron girders. The front wheels are of the caster type and it is stated that they will trail when in trains. Both front and rear wheels are provided with Hyatt heavy-duty roller bearings and arranged for Alemite lubrication.

The trailers are equipped with a Clark automatic coupler hitch at each end. This hitch is shown in detail in the upper section of the accompanying illustration. These trailers have a rated capacity of 4,000 lb. and weigh 500 lb. according to the manufacturer.

Variable-Speed Driving Gear

ANNOUNCEMENT has been made that the P.I.V. (positive, infinitely variable) variable-speed driving gear, shown in the accompanying illustration, is being manufactured by the P.I.V. Gear Syndicate, Ltd., 7 Princes St., Westminster, London, England, and the



P.I.V. variable-speed driving gear

world rights are being handled by Messrs. Close Bros., Ltd., Basildon House, 7 Moorgate, London, E. C. 2, who will soon establish an American company to manufacture it. This gear, it is said, allows an indefinite number of speed variations to be given to a driving shaft with positive transmission on any centers, and is adjusted by a single handle.

The essential principle of the design of the P.I.V. gear is the use of a driving chain of special construction, operating on any center distances down to only a few inches if necessary, which in the standard design runs between expanding pulleys of the opposed, conical-disk type sloping on the inner face to the center, broader at the periphery and narrower at the hub. The two faces are staggered in the sense that a rib is always opposite a groove. The chain is engaged at the edges by these ribs, which act as teeth in such a manner that the drive is said to be truly positive.

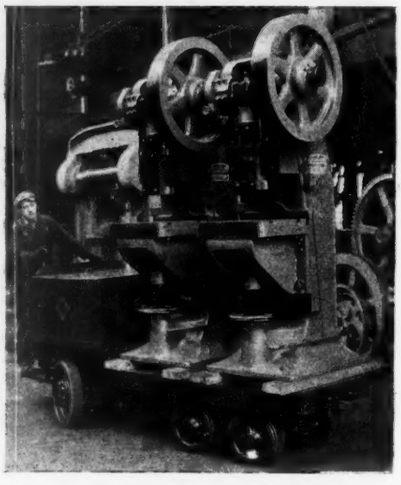
The links are connected by rivets as usual, but a longitudinal slot is punched through them, and in this is fitted a sleeve containing small, thin steel plates or slats fixed vertically and loose in the sense that they can move in a direction at right angles to the travel of the chain. These slats project on either side, and as a link enters the V of the pulleys the ribs or teeth of one pulley face push the requisite number of slats across into the spaces between teeth on the opposed pulley face, so that the chain always engages positively in all positions with the driving pulleys.

Increase in Stock Sizes of Silent-Chain Drives

STOCK sizes of Link-Belt silent chains are now available from distributors in ratings from ¾ to 15 hp. in almost any reduction from 1:1 up to 7:1, according to an announcement by the Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill. Formerly the stock sizes carried did not exceed 10-hp. rating. These stock drives do not, the announcement adds, interfere in any way with drives that this company furnishes in sizes up to 1,000 hp. or over.

10-Ton Electric Lift Tructor

ANNOUNCEMENT of the Super-Lift Tructor is made by the Elwell-Parker Electric Co., Cleveland, Ohio, as the latest addition to its mill-type series. This tructor is driven by storage batteries delivering power through Elwell-Parker, drum-type controllers of new design to Elwell-Parker motors. The machine, shown in the accompanying illustration, weighs, complete with battery, approximately 6,100 lb. and, it is stated, will not only pick



Elwell-Parker Super-Lift Tructor

up but carry 20,000 lb. at the rate of 300 to 400 feet per minute.

The construction and operation as described by the manufacturer are as follows: The lift mechanism consists of a special motor direct-connected to a single-worm reduction with a nut built into the hub of the worm wheel. A forged multi-thread worm or screw-lift ram travels in and out of this nut, simultaneously lifting or lowering the load. This lift ram is a one piece forging and raises and lowers the heavily re-inforced, all-steel platform.

The tandem trail axle carries four wheels each of which is fitted with two differentiating tires to provide proper creep when being steered. All four wheels steer simultaneously and concentrically with the two larger drive wheels located beneath the battery. Each of the four wheels is fitted with

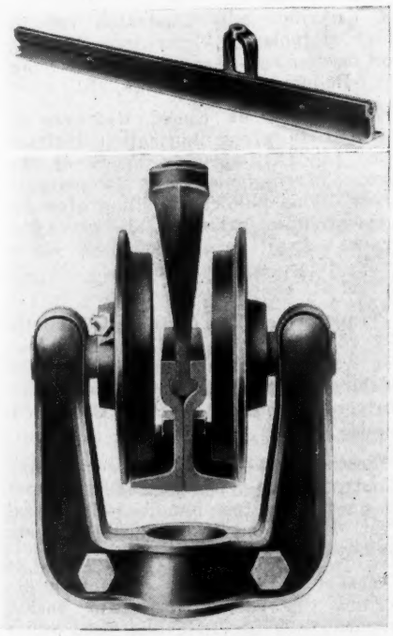
two heavy tapered roller bearings carried on independent drop-forged hubs with special heat-treated alloy steel knuckle pins within.

The lift motor is fitted with a special electro-mechanical brake and the complete lift mechanism may be removed from the tructor as a unit. The main drive unit is built with disk wheels on double-row ball, radial and thrust bearings and carries special 22-in. by 6-in. solid rubber tires. Among the applications of this tructor are transferring heavy tools, molten metal ladles, rolls, slabs, pig iron and ingots, as well as handling sheet steel in 10-ton units.

Monorail Track

A NEW and distinctive rail design for overhead hand-power monorail systems is announced by The American MonoRail Co., W. Sixty-seventh St. and Pear Ave., Cleveland, Ohio. Features include a two-part rail, clamped together by means of bolts seated in slotted holes, suspending hangers assembled with the rail, and the elimination of splice clamps by staggering the joint of the two side members of the rail. Unusual carrying capacity which permits wide spacing of hangers and bridging of wide spans is claimed. The assembly of the hangers as part of the monorail sections is stressed as materially reducing cost of installation.

The construction of the rail may be noted from the illustration. It consists of two twin sections rolled from railroad rail steel. The sections are bolted together, back to back, to form a solid rail unit. The high vertical web of the rail is intended to provide maximum carrying strength, while the narrow over-all width dimension of 2 in. facilitates bending of the rail in the field to meet layout requirements. Holes for the clamping bolts are slotted to relieve the bolts of sheer stresses as the sections are being bent. Standard bent sections are furnished for all regular curves and for irregular bends on order.

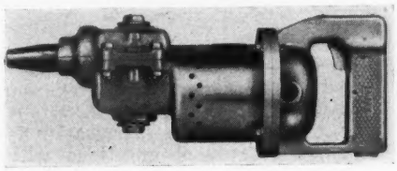


Monorail track manufactured by The American MonoRail Co.

The supporting hangers are steel forgings and are adapted to plain strap or adjustable bolt suspension. They are assembled in the rail head, as shown, and shipped as part of the rail sections. The standard spacing of the hangers can be shifted to meet suspension requirements.

Portable Electric Hammer

MARKETING of the Ajax, portable, Type B-2 electric hammer is announced by the Ajax Electric Hammer Corp., 117 W. Sixty-third St., New York, N. Y. This unit weighs approximately 10 lb., is driven by a universal motor consuming 220 watts, and can be operated directly from any electric lighting circuit. This hammer was designed primarily for drilling and chipping materials, such as brick, stone, and cement, and chipping metals, but it is also adaptable to many other fields. A chuck which holds standard tapered shank drill points fits directly in the hammer and is provided with a handle for rotating the drill while in operation.



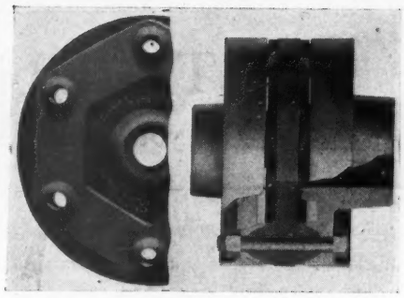
Ajax portable electric hammer.

The mechanism, as described by the manufacturer, consists of only three moving units: motor, crankshaft and plunger, which are housed in an aluminum frame. The crankshaft is driven at right angles to the motor by a 4.75 : 1 bevel gear reduction. Extending from the face or end of the crankshaft is a hardened steel pin and roller which operates in a curved slot cut in the face of the plunger, imparting to it a reciprocating movement. Approximately two-thirds of the revolution of the pin is devoted to lifting the plunger and one-third to throwing it with accelerating velocity against the tool head. As the plunger is thrown and not forced against the tool head no shock is transmitted to the gears or motor. With this method of operation it is claimed that it is impossible to overload or stall the motor and that the hammer delivers approximately 2,400 blows per min. independent of the size of drill or chisel being used. The drilling speed of this hammer with a 1-in. drill in hard concrete is about 2 in. per min., it is stated.

Cord Disk Flexible Couplings

IMPROVEMENTS on the old-type flat disk in a flexible coupling have been announced by the Climax Motor Appliances, Inc., 7016 Euclid Ave., Cleveland, Ohio.

This new Climax cord disk, a section of which is shown at the left in the accompanying illustration, deviates from the old type flat disk in that improved features have been incorporated in the raised cord links extending from bolt to bolt, which, it is stated, add considerable strength and durability.



Left, raised links and semi-spherical bosses on disk. Right, assembly of coupling.

The semi-spherical rubber bosses at the bolt intersection are integral with the disk and are used as driving members. The metal members used in connection are formed to fit the bosses on the one side, and on the reverse side special cup washers are provided, as shown in the cut-away view of the clutch at the right in the accompanying illustration. This construction, it is stated, overcomes the difficulty experienced in using a flat washer by eliminating the critical angularity of the working clearances between the washer diameters; also, this construction makes it possible to transmit the maximum torque without fear of destruction.

These disks are made up for industrial use in sizes from 5½ in. to 16 in. outside diameter, and permit the coupling hubs to be made in various sizes so as to accommodate shafting from ⅜ in. to 8 in. in diameter. The manufacturer states that power can be transmitted under the most severe conditions, for instance on a fixed angle of 3 deg., on the order of ¼ hp. for the 5½-in. disk to 30 hp. for the 16-in. disk, at 100 r.p.m. Under favorable conditions it is stated that the rating could be increased to as much as seven times this.

Water Temperature Regulators for Electric Heaters

A NEW device for controlling automatically the operation of electric water heaters has recently been perfected by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. The control is effected by a Spencer disk thermostat which is actuated by the heated water passing over a thin metal plate placed in contact with the thermostat.

This new thermal regulator consists of the Spencer thermostat mounted in a bronze cast pipe housing above the electric heater. When the heater is turned on, the water passes over it and then through the section of pipe containing the regulator. Until the temperature of the water has reached the upper limit of operation of the thermostat, the heater stays on, but when that limit is reached, the heater is turned off by the thermostat breaking the contact. As soon as the temperature of the water falls below the lower limit of the thermostat, the contact is made again and the heater turned on.

Trade Literature
you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Industrial Lubrication—A 48-page booklet discusses the various types of Alemite fittings and compressors for applying grease under pressure.—The Bassick Mfg. Co., 2650 N. Crawford Ave., Chicago, Ill.

Rawhide Pinions—A 56-page catalog gives numerous tables and rules for the application of rawhide gears. In addition, prices are quoted on gears and gear blanks.—The Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago, Ill.

Industrial Products—Bulletin 43 describes and lists the industrial gears and flexible couplings made by this company.—R. D. Nuttall Co., Pittsburgh, Pa.

Mica Insulation—A booklet entitled, "Micabond—the Modern Mica," describes the various forms of Micabond supplied by this company for electrical insulation.—Chicago Mica Co., Valparaiso, Ind.

Acetylene Welding—The instruction book on the care, operation and use of the No. 6 Smith torch contains interesting and instructive information for all users of acetylene welding equipment. — Smith Welding Equipment Corp., Minneapolis, Minn.

Pneumatic Tubes—Catalog 2175 describes and shows numerous installations of the G & G Atlas pneumatic tube system.—G & G Atlas Systems, Inc., 535 W. Broadway, New York, N. Y.

Fume Recovery—Bulletin 14 describes and shows the construction of the Dracco Twentieth Century baghouse for fume recovery.—The Dust Recovering and Conveying Co., Harvard Ave. and E. One Hundred Sixteenth St., Cleveland, Ohio.

Vaporproof Condulets—Folder 42 illustrates and describes the various conduit fittings made by this company for use around inflammable vapors or gases. —Crouse-Hinds Co., Syracuse, N. Y.

Wiring Devices—Catalog 22 covers the line of wiring devices such as plug-line attachments, plates, receptacles, rosettes, sockets and socket switches, and fixture and wall switches.—The Arrow Electric Co., Hartford, Conn.

Chain Drives—Book 812 illustrates and describes a number of applications of Link-Belt silent chain drive for machine tools.—Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

Conveyors—A book of 120 pages entitled, "Bearing the Burden of Industry," describes and illustrates, with photographs of installations and with drawings of the detailed construction features, the installation and application of Mathews roller, sheet-metal spiral, belts and chain conveyors in a variety of industries. A large amount of descriptive data is included in addition to the numerous sketches and drawings.—Mathews Conveyor Co., Ellwood City, Pa.

Angle-Forming Equipment—A circular describes the use of Whitney ball-bearing punches, shears and a special angle-iron combination for punching, cutting, and bending light angle-iron and flat steel.—Whitney Metal Tool Co., 91 Forbes St., Rockford, Ill.

Electric Refrigeration — Booklet AF190 describes and illustrates several different styles and types of Frigidaire water cooling systems for industrial and other use.—Delco Light Co., Dayton, Ohio.

Lubricator—A 48-page booklet gives a description of the use and covers the advantages claimed for the Keystone Safety lubricator. This information is given in the form of questions with answers and descriptions of typical installations.—Keystone Lubricating Co., Philadelphia, Pa.

Material Handling Equipment — A leaflet entitled, "Keep Your Product Moving," illustrates the application of some of the large-sized electric tram-rail systems.—The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Line Hardware—An 8-page folder issued monthly under the title, "The Line," illustrates and descrbies various transmission equipment, hardware, and supplies manufactured and distributed by this company.—Line Material Co., South Milwaukee, Wis.

Babbitt Bearings—Application of alloy No. 25 in the babbitting of bearings is described, and the use of Westinghouse electric babbitting pots is discussed, in Folder 4474.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Power Factor—An 82-page publication, No. 1010, entitled "The Power Factor Book," explains and illustrates from many angles facts that lead to a clear understanding of the meaning and effect of power factor.—The Electric Machinery Mfg. Co., Minneapolis, Minn.

Chain Drive—Folder B-60 entitled, "Fitting the Drive to the Job," illustrates a variety of applications of Whitney silent chain drives. — The Whitney Mfg. Co., Hartford, Conn.

Knife Switches—Reinforced switch and fuse contacts, approved by Factory Mutual Laboratories, are described and illustrated in a leaflet, which also lists the prices of the various types of clips. —Reinforced Switch & Mfg. Co., Pittsburgh, Pa.

Electric Heating Units—Chromalox heating units as applied to airheating are described and illustrated in Bulletin C-108. Bulletin C-106 is devoted to industrial and commercial applications of these heating units.—Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa.

Ball Bearings in Motors—A 20-page book entitled, "Cutting Your Costs, or What New Departure Ball Bearings Mean in Your Motor," discusses the advantages of using ball bearings in motors and gives numerous illustrations of such application, together with economies, which it is said, have resulted from their use.—The New Departure Mfg. Co., Bristol, Conn.

Supervisory Control — A circular C-1694-B gives a clear description of the principles involved in supervisory control and the equipment used.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Condulets—Various types of plug receptacles and safety switch condulets are described and illustrated in Folder No. 43. Bulletin No. 2093 describes and lists the prices of Type MT safety switch condulets.—Crouse-Hinds Co., Syracuse, N. Y.

Clutches—The CM 4 clutch used on a wide variety of low-powered machines is described and illustrated in Bulletin No. 40.—The Conway Clutch Co., 1940 Riverside, Cincinnati.

Self-Starting, Squirrel-Cage Motors —A circular describes the type H-O (Hanson - Oesterlein) self - starting, squirrel-cage motor which, it is stated, has only one rotor winding.—Northwestern Mfg. Co., Milwaukee, Wis.

Gas Heater — An industrial gas heater used for tempering, lead melting, and the like is described and illustrated in a leaflet.—L. J. Van Guelpen Co., Cincinnati, Ohio.

Hand Tools—A 56-page catalog, No. 26, describes and illustrates various kinds of tools for electricians, linemen and mechanics.—Mathias Klein & Sons, 3200 Belmont Ave., Chicago, Ill.

Lubrication of Speed Reducers — Form L-28 gives lubrication instructions for IXL speed reducers of the spur-, herringbone-, and worm-gear types. This publication illustrates the lubrication requirements and gives the grades of oil recommended. — Foote Bros. Gear & Machine Co., 220 N. Curtis St., Chicago, Ill.

Transformer Tap Changers—Bulletin No. 136 describes and illustrates Wagner transformer tap changers as used on large distribution and power transformers.—Wagner Electric Corp., St. Louis, Mo.

Testing Sets—A leaflet describes and illustrates two types of trouble shooter test sets, and test handles.—Universal Test Equipment Co., 2939-41 North Oakley Ave., Chicago, Ill.

Socket Wrench Sets—A folder describes the various types of socket wrench sets for industrial and other work. — Husky Wrench Co., Twenty-Seventh and Florence Sts., Milwaukee, Wis.